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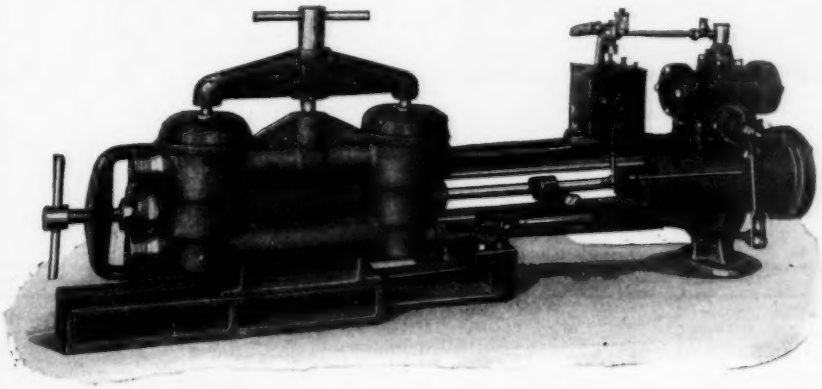

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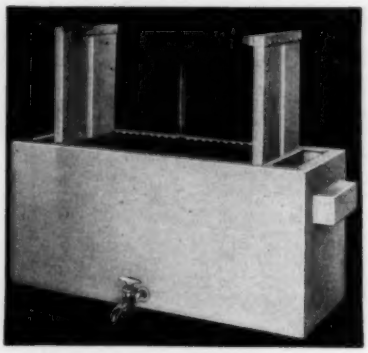

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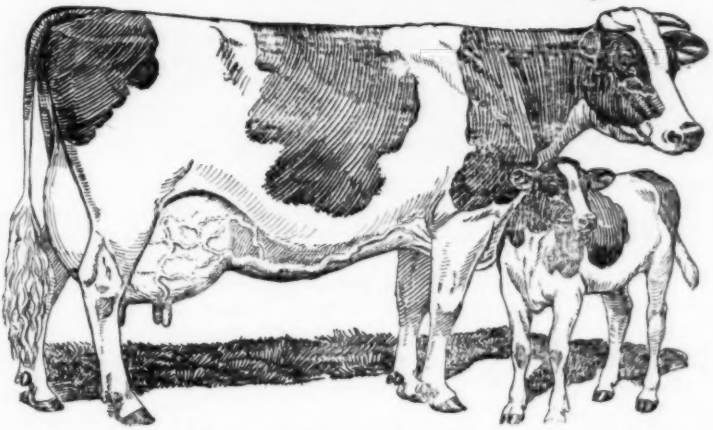

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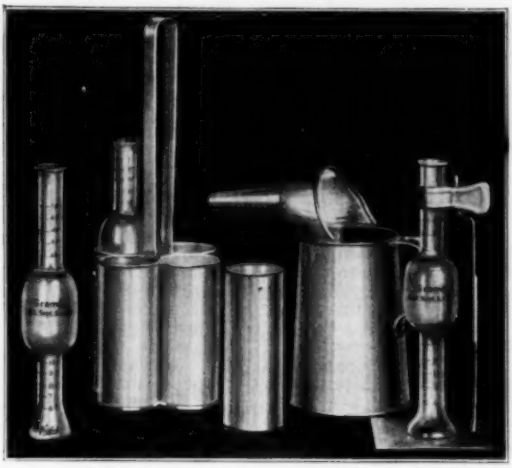

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Hot weather imposes the need of extraordinarily effective methods of sterilization. Here is a farmer whose milk cans, alive with bacteria after a few hours in the summer sun, are unfit to receive new milk and cream; there is a cheese factory reeking with bad odors and mould, baffled with the perplexing problem of stinker and gassy cheese during the very months of the year that should be peak months in production; another place, a milk plant, whose owners must stand helplessly by and take great losses in money and trade because their milk and cream cannot stand the severe tests of the summer months.

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THE EFFECTS OF UNDERFEEDING ON MILK SECRETION

ARTHUR C. RAGSDALE AND CHARLES W. TURNER

Department of Dairy Husbandry, University of Missouri, Columbia, Missouri

Received for publication, February 12, 1923

It has been shown by Eckles and Palmer (1) that underfeeding has a marked influence on the composition of milk. They recognize three types of underfeeding: (*a*) the withdrawal of a certain portion of the total food of the animal, (*b*) the reduction to a normal plane of animals on a supernormal plane of nutrition, and (*c*) the physiological underfeeding resulting from the strong stimulus for milk secretion during a number of days after parturition when it is not possible for the appetite of the cow to supply the demands for nutrients to support both the milk flow and her body weight.

It was found in all of their experiments that a high fat test accompanied the reduction in the plane of nutrition; and the effect was greatest in the cases of greatest reduction. The increase in the percentage of fat was especially marked when the cow had been on the supernormal plane of nutrition for a considerable period before the reduction of the plane. The influence of physiological underfeeding (2) has been recognized in making large short time official records during which time an abnormally high test results.

The object of this paper is to present data showing the effect of the first two types of underfeeding especially as they affect the reliability of the two-day semi-official yearly record.

Three cows, a Jersey, a Holstein-Freisian, and an Ayrshire, in the first half of their lactation period were selected for the first experiment. Before being placed on experiment, it was found that the cows were on a supernormal plane of nutrition as determined by weighing all hay, grain and silage during a three-day preliminary period.

Following the preliminary period, the cows were put on a ration calculated to furnish as nearly as possible exact requirements as determined by the feeding standards, They received a ration composed of alfalfa hay, silage, and a grain mixture. This ration was continued for ten days. One half of each constituent in the ration was then removed and the reduced ration continued for ten days. The original amount of feed was then again gradually given.

The results are shown in table 1 and chart 1. It will be seen that there is a very decided increase in the per cent of fat in the milk when the ration was reduced one-half. The maximum per cent of fat occurred during either the second or third day after the reduction in feed was made. While there was some variation in the tests after reaching the high point, they remained considerably above normal during the remainder of the period. As soon as the cows were put back on full feed, the per cent of fat in each case went down very rapidly and decidedly and remained considerably below normal during the following ten day period.

The quantity of milk produced was decidedly affected in the opposite way. The greatest reduction in milk occurred the second day after the reduction in the feed, followed by a gradual decline throughout the period. When the cows were brought back to full feed they gradually increased in production but did not reach that of the three day preliminary period during the following ten days.

The increase in the per cent of fat was not sufficient to cause an increase in the total amount of fat due to the reduction of milk.

The weight of the cows in the group was reduced considerably during the reduction in the feed, averaging 78 pounds per cow.

It is commonly thought that a feverish condition of a cow may be a cause of the increase in the per cent of fat in the milk. To determine whether underfeeding would cause a feverish condition, the temperatures of the animals were taken at each milking. The figure recorded is the average of these readings. It will be noted that feed reduction did not produce a feverish

TABLE 1

The effect of feed reduction on milk secretion

DATE	AVERAGE MILK PER DAY	TRUE AVERAGE FAT	AVERAGE FAT PER DAY	BODY TEMPERATURE	AVERAGE WEIGHT OF COWS
1920	*pounds*	*per cent*	*pounds*		*pounds*
February 19	38.7	4.051	1.569	101.03	
February 20	40.3	3.869	1.561	101.22	
February 21	39.7	4.259	1.692	101.00	
Average	39.6	4.059	1.607		884
February 22	40.3	3.862	1.558	101.03	
February 23	37.8	4.070	1.539	100.77	
February 24	36.7	4.280	1.572	100.77	
February 25	37.5	4.052	1.521	100.86	
February 26	36.5	3.916	1.430	100.78	
February 27	36.8	4.062	1.495	100.97	
February 28	35.8	3.918	1.402	100.57	
February 29	34.4	4.304	1.481	100.77	
March 1	36.5	3.615	1.318	101.02	
March 2	34.2	3.777	1.293	100.62	
Average	36.7	3.985	1.461		891
March 3	36.8	3.772	1.387	101.09	
March 4	28.6	4.500	1.289	100.27	
March 5	28.1	4.849	1.363	100.46	
March 6	27.3	4.494	1.227	100.11	
March 7	25.8	4.366	1.127	100.66	
March 8	25.0	4.531	1.131	100.99	
March 9	24.8	4.591	1.140	101.66	
March 10	25.7	4.440	1.141	102.03	
March 11	25.5	4.687	1.194	100.62	
March 12	26.4	4.560	1.120		
Average	27.2	4.453	1.212		813
March 13	23.6	4.363	1.031	101.20	
March 14	28.1	3.801	1.067	100.89	
March 15	28.9	3.717	1.073	101.27	
March 16	31.4	3.673	1.153	100.84	
March 17	33.8	3.710	1.254	101.01	
March 18	32.8	3.625	1.189	101.12	
March 19	33.2	3.624	1.203	101.02	
March 20	34.1	3.582	1.222	100.89	
March 21	35.2	3.563	1.254	100.82	
March 22	34.3	3.823	1.313	101.04	
Average	31.5	3.728	1.176		900

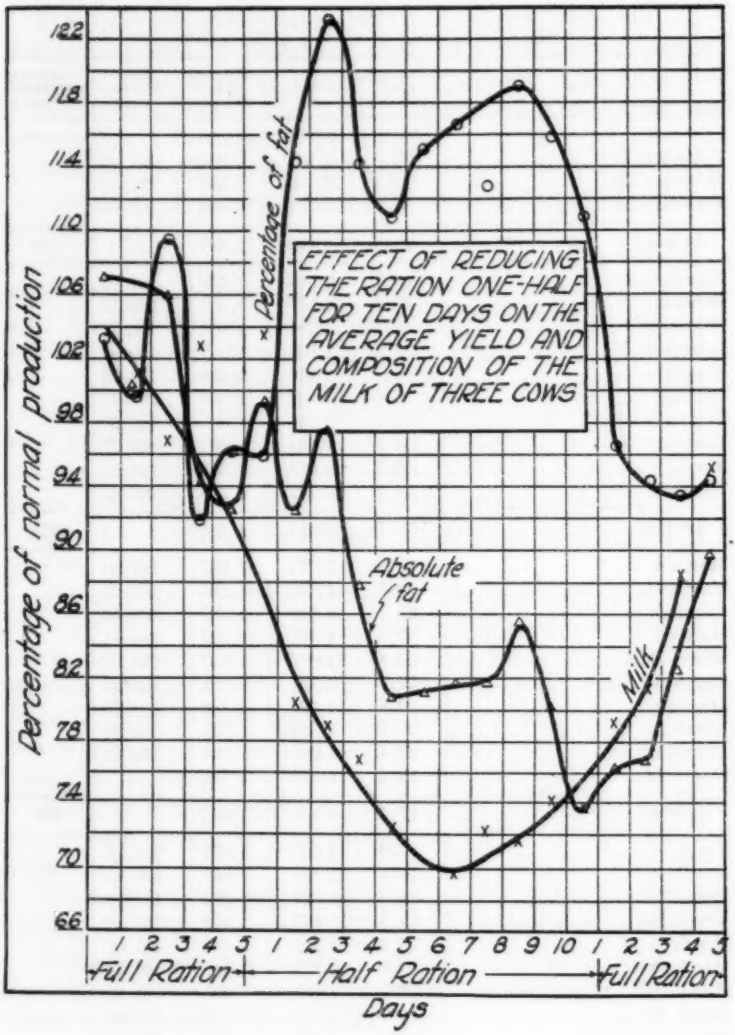
EFFECT OF REDUCING THE RATION ONE-HALF FOR TEN DAYS ON THE AVERAGE YIELD AND COMPOSITION OF THE MILK OF THREE COWS
Percentage of fat
Absolute fat
Milk
Percentage of normal production
122
118
114
110
106
102
98
94
90
86
82
78
74
70
66
1 2 3 4 5 1 2 3 4 5 6 7 8 9 10 1 2 3 4 5
Full Ration
Half Ration
Full Ration
Days

CHART 1

condition of the animals during the ten days of the reduction. One cow bloated during this period and showed a slightly increased temperature for three days.

These results show that there is a considerable increase in the per cent of fat during the second and third days following feed reduction. As only three cows were used, the results were checked by using a larger number of animals in varying stages of lactation. Table 2 gives a description of the cows.

During a three day preliminary a full feed was given similar to that previously fed and complete records were kept. The fourth day each constituent of the feed was cut exactly 50 per

TABLE 2

Description of cows

COW NUMBER	MONTH OF LACTATION	BREED	AVERAGE DAILY MILK PRODUCTION AT START OF EXPERIMENT
			pounds
64	2	Jersey	35
110	2	Jersey	25
121	8	Jersey	14
129	6	Jersey	24
275	4	Holstein	32
282	9	Holstein	19
288	9	Holstein	10
325	2	Ayrshire	34

cent. This feed reduction was continued for three days, after which the plane of feeding was again returned to normal. Table 3 shows the results. It will be seen that the per cent of fat again showed a very decided increase by the third day on the reduced ration. This increase was followed by a decrease in the per cent of fat shortly after the feed was returned to normal.

The flow of milk did not appear to be reduced as much in this experiment as in the year previous. This is partly accounted for by the fact that some of the cows were more advanced in lactation and were not producing heavily. It appears that the cows producing large amounts of milk are affected more by the cut in the feed than those producing only a limited amount of milk.

The total fat production was not increased by the feed reduction as the milk flow was sufficiently reduced to counterbalance the effect of the increase in the per cent of fat.

The findings indicate that in the case of cows on yearly test the average per cent of fat during the two-day test can be influenced by reducing the feed of cows on test two days previous.

In view of the peculiar effect of underfeeding on the per cent of fat, this factor should be considered in interpreting data on

TABLE 3

The effect of feed reduction on milk secretion

DATE	AVERAGE DAILY MILK PRODUCTION—8 COWS	TRUE AVERAGE FAT—8 COWS	AVERAGE DAILY FAT PRODUCTION—8 COWS	MEAN ATMOSPHERIC TEMPERATURE FOR THE TWENTY-FOUR HOURS
		per cent		
March 12	23.02	4.805	1.106	50
March 13	24.61	4.514	1.111	57
March 14	24.98	4.384	1.095	60
March 15	24 70	4.700	1.161	60
March 16	22.08	4.524	0.999	47
March 17	21.20	5.137	1.089	58
March 18	21.51	4.826	1.038	64
March 19	23.56	4.334	1.021	70
March 20	23.76	4.192	0.996	69
March 21	23.50	4.268	1.003	41
March 22	23.07	4.516	1.042	43
March 23	22.56	4.486	1.012	48
March 24	23.17	4.536	1.051	55

the possibility of increasing the per cent of fat by the administration of drugs. If cows go off-feed due to the administration of drugs there is the possibility of the per cent of fat increasing due to the self-reducing plane of nutrition as well as to the influence of the drugs.

The effect of underfeeding as it influences experiments of other types was shown very clearly in work being carried on at this station (3) to show the correlation between the atmospheric temperature and the per cent of fat in milk. The data up to the

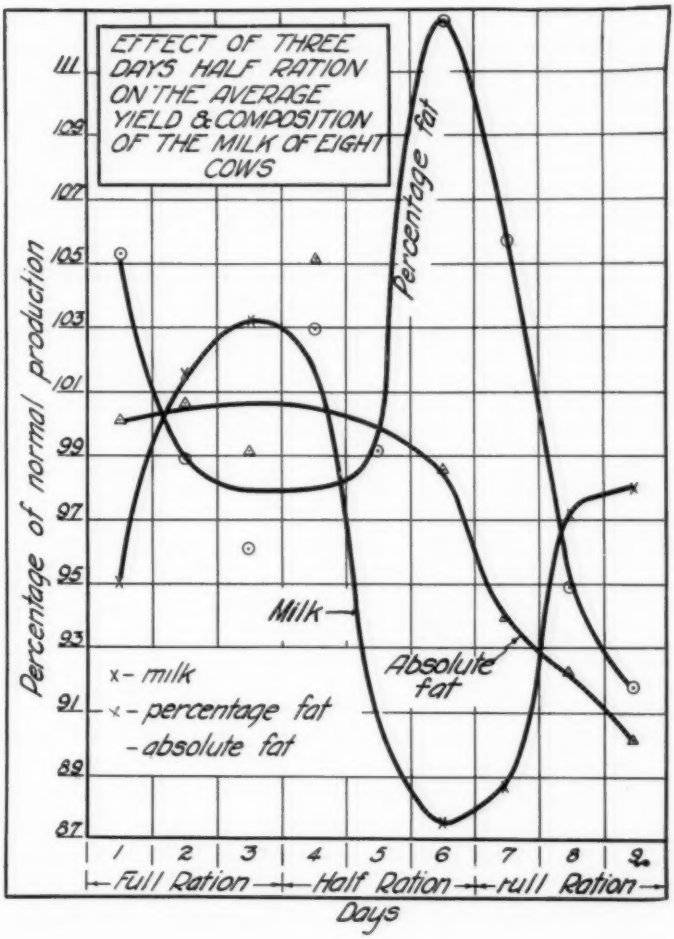

CHART 2

time the cows were placed on pasture indicate that there was a causative relation between temperature and the percentage of fat in milk, showing roughly an increase of about 0.15 per cent of fat for a decrease in the temperature of 10°F. The cows on

this experiment were turned to pasture May 3, 1921. Table 4 shows that there was a significant increase in the per cent of fat following that day which could not be accounted for by the temperature. It is believed that the underlying cause of the increase was due to underfeeding resulting from the fact that

TABLE 4

The effect of pasture on the per cent of fat in milk

DATE	MEAN ATMOSPHERIC TEMPERATURE FOR TWENTY-FOUR HOURS	TOTAL MILK PER DAY—AVERAGE 10 COWS	TRUE AVERAGE FAT PER DAY—AVERAGE 10 COWS
			per cent
April 23	65	26.16	4.63
April 24	73	26.47	4.72
April 25	71	26.35	4.83
April 26	50	25.95	4.64
April 27	32	25.95	4.86
April 28	50	24.93	4.77
April 29	50		
April 30	53	25.72	4.73
May 1	46	25.37	4.85
May 2	46	24.6	5.26
Cows turned to pasture			
May 3	47	24.1	5.19
May 4	51	24.9	5.19
May 5	56	24.4	5.50
May 6	58	24.6	5.28
May 7	60	27.5	5.20
May 8	58	24.2	5.31
May 9	63	25.5	5.20
May 10	62	24.8	5.47
May 11	60	25.3	4.82
May 12	63	26.0	5.24
May 13	60	27.3	5.01

fresh pasture grass has a high water content which makes it impossible for a high producing cow to consume sufficient nutrients to satisfy her requirements. Furthermore it takes some time for the animals to become accustomed to foraging after stall feeding during the winter. This results in underfeeding for a short time with the resulting affect on the per cent of fat.

SUMMARY

It was shown that when the ration fed to dairy cows was reduced 50 per cent that there was a decided increase in the per cent of fat in the milk. The peak of the increase in the per cent of fat was reached about the third day. The per cent of fat remained abnormally high as long as the reduced ration was continued (ten days). When the ration was brought back to normal the per cent of fat decreased and remained below that of the preliminary period during the entire ten-day period.

The quantity of milk produced was reduced, the amount of reduction depending on the length of the feeding period and the stage of the lactation period.

The total yield of fat was not significantly changed.

Underfeeding did not appear to cause a feverish condition of the udder.

The effect of underfeeding should be taken into consideration in interpreting data on feeding trials of short duration, the effect of drugs on the per cent of fat, pasture experiments, and other experiments of this type where significance is placed upon a variation in the per cent of fat.

CONCLUSIONS

1. It is possible to materially increase the per cent of fat in the milk of cows during the two-day test made in connection with yearly semi-official records. Greater care should, therefore, be exercised by those in charge of this work to prevent advance information reaching the breeder as to the exact time the test will start.

2. As the total amount of fat is not materially increased, and may be decreased it is of little or no value to reduce the feed on a seven day test in an attempt to increase the total daily production of fat.

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COPPER IN DAIRY PRODUCTS AND ITS SOLUTION IN MILK UNDER VARIOUS CONDITIONS

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INTRODUCTION

There are many flavor defects in milk products that have been attributed by investigators to the presence of copper or other metals. Seldom is the flavor directly from the metal itself but through what has been supposed to be a catalytic effect some of the milk constituents are broken down and compounds with disagreeable odor and taste are produced.

In 1905 Golding and Feilman (1) described an "alkaline mealy flavor" which they found in certain samples of market milk. The trouble was traced to the use of a cooler from which the tin was worn thus exposing a copper surface; the presence of small amounts of copper dissolved in the milk together with the activity of certain organisms was believed to be the cause of the development of the peculiar flavor. The fact that the flavor was noted only after about sixteen to eighteen hours gave proof that it was not due to the copper salt itself, but that the copper in some way caused or assisted in a change which resulted in the formation of a substance which rendered the flavor objectionable. Rogers, Berg, Potteiger and Davis (2) investigated very thoroughly the flavor of butter obtained from cream which had been allowed to become contaminated with copper as well as iron. They found that "in every instance the scores on the control butters were better than the scores on the butter made from cream to which copper had been added, even in the small amount of 1 mgm. of copper per kilo of cream." Hunziker and Hosman (3) by allowing butter to stand in contact with certain metals and their hydroxides found tallowiness developing invariably when copper was the metal. Palmer

and Combs (4) added copper lactate to cream in small amounts and proved that butter made from this cream became tallowy. Results similar to those just described have been reported also by Rosengren (5).

Olson (6) found that the action of rennet on milk was slowed down by the presence of copper and Gerber (7) reported that among other salts those of copper affected the rate of coagulation of milk by various vegetable and animal ferments.

Hess (8), and Hess and Unger (9) have recently discovered the interesting fact that where milk has become contaminated with copper the activity of the antiscorbutic vitamine is reduced.

Aside from the proof given in these published reports of investigations on the evil effects of copper contamination on milk products it is also well known that in the trade most of the unexplained defects in dairy products have been attributed to this factor, for instance, the strong flavor developing in powdered whole milk after a few months in storage has been thought by manufacturers to be caused at least partly by the presence of copper. Certain observations have been made in this laboratory also which indicate that unusually large amounts of copper in sweetened condensed milk can cause tallowiness in that product.

Changes brought about by the contamination of copper and other metals on foods other than dairy products have been demonstrated by various investigators particularly by Emery and Henley (10). They have pointed out what seems to be generally true, that the metals themselves do not bring about the decompositions except in presence of air or oxygen.

The activity of such metals as copper which assist in oxidative changes has led to the use of the term "oxygen carrier." The practice has long been made of adding copper in Kjeldahl digestions to hasten the oxidation of the organic material. The catalytic activity of copper in various organic and inorganic reactions is well known. Golding and Feilman (1) seemed to suspect that the defect which they noted in market milk resulting from copper contamination was related to an oxidative process since a similar flavor could be produced by adding oxidiz-

ing agents such as hydrogen peroxide. Also most of the investigators mentioned above have considered the changes from that point of view.

Since copper has been found to be such a dangerous impurity in milk products it seems important to know something about how it gets there in the first place, and with this knowledge to devise means of keeping it out if possible. Inasmuch as such equipment as pasteurizers, coolers, and sanitary pipe are usually constructed of copper coated with tin there is always the possibility of the tin wearing through, leaving the copper surface in contact with the milk. Furthermore in the manufacture of condensed, evaporated and powdered milk and ice cream mixes, copper hot wells and vacuum pans are ordinarily employed. Chemical analysis is not necessary to show that copper is dissolved by the milk from this equipment as it can always be noticed that the surface of a copper hot well or pan is brighter and smoother in appearance after contact with hot milk than before.

Copper as a normal constituent of cow's milk has been reported by some investigators while others have thought it not to be naturally present. Of course this might be expected to vary as the copper content of the feed of the cow changes. Some recent work by Supplee and Bellis (11) indicates that copper may be expected naturally in cow's milk to the extent of about 0.52 part per million on the average.

The purpose of this work was to consider whole milk merely as a solvent and to determine the amount of copper dissolved in the fluid when in contact with the metal under various conditions. From this point of view Golding and Feilman (1) made a few experiments to determine the influence of air on the solubility and it was found that bubbling air through the milk, or suspending copper gauze at the surface of the milk increased enormously the amount of copper dissolved. Upon pasteurizing milk in a copper vessel at 145°F. for one-half hour Hess (8) found the milk to contain "three or four parts of copper per million."

Donauer (12) by weighing strips of metal before and after contact with fresh milk, sour milk and 0.2 per cent lactic acid found much more of the metals dissolved at pasteurizing than at lower temperatures. Many of the metals, including copper, were attacked by fresh milk to about the same extent as sour milk. Also, Supplee and Bellis (11) made some observations on the amount of copper taken up by milk during handling in milk plants. Passage of milk through sanitary piping from which the tin was worn resulted in an increase in copper content as much as 2 mgm. copper per liter. Condensing in copper vacuum pans caused an increase in copper in the milk of from 0.38 to 2.98 mgm. per liter, and after storing milk in copper containers for twelve hours at 45°F. it was found to have taken up 1.21 mgm. of copper per liter, and for two hours at 150°F.—4 mgm. per liter.

EXPERIMENTAL

Except where otherwise stated, strips of pure copper were used giving 140 square inches of surface. After allowing 2000 cc. of good fresh milk to stand in glass flasks in contact with the metal under the conditions of the experiment, the milk was poured off and evaporated to dryness. The residue was ignited in a muffle furnace and the ash dissolved in a small quantity of nitric acid. The copper in solution was determined electrolytically, and in some cases where the quantity of copper was extremely small it was dissolved off the gauze electrode and run colorimetrically by the potassium ethyl xanthate method (13).

In making the electrolytic separation directly from the solution it was sometimes found that a good deposit was not obtained, so that the practice was adopted of depositing the copper first on one of the gauze electrodes, than after washing out the solution with water acid was added and the current reversed. In this way the cathode could be covered with a smooth deposit of good color.

Particular care was taken to have the water and all reagents used free from copper. In a great many of the experiments copper determinations were made on portions of the untreated

milk as checks. All these analyses gave results very close to 0.5 mgm. per 1000 cc. and this figure was always subtracted from the results. The milk was obtained from the salesroom of the College of Agriculture and no observations were made as to the character of the equipment through which it had passed from the time it was drawn from the cow. Therefore, it could not be certain in this instance that the milk had not taken up some copper in handling. Yet it is interesting to note that the above figure is very near to that found by Supplee and Bellis as the amount of copper normally present in cow's milk.

All milk used in any given experiment was from a single composite sample. While each experiment in practically all cases represents a different tank of milk from every other one.

Effect of air and oxygen on the solvent action of milk

Experiment 1. Three portions of milk were heated at 140°F. with copper strips for one hour. In sample 1 the flask was merely shaken from time to time. Through 2 air was bubbled throughout the heating period and in sample 3 pure oxygen was passed similarly. Amount of copper dissolved by the milk in milligrams per liter follows:

	mgm.
Sample 1	5.45
Sample 2	25.15
Sample 3	lost

While flask 3 was broken near the end of heating period it was apparent that an enormous amount of copper had been dissolved for the milk had become intensely blue.

These results substantiate those of Golding and Feilman showing that oxygen and air increase to a great extent the amount of copper dissolved by milk.

It should be noted in this connection that copper has been found (14) to be dissolved by organic acids only when a supply of air is afforded. However, this example is not exactly parallel to that of the action of milk since perfectly fresh milk is believed to contain no free organic acid. Also, Emery (15) has shown that oxygen assists in the solution of some metals in fats.

Solution from a smooth bright copper surface compared with one darkened by an oxide incrustation

Experiment 2. Half of the copper strips were coated with oxide by holding for an instant in the blue flame of the Bunsen; the others were well polished. By immersing in the milk for one hour at 140°F. the following amounts of copper were found to be dissolved in milligrams per liter:

	mgm.
Bright copper	5.45
Darkened copper	19.90

Experiment 3. In this case the copper strips were treated by immersion in chlorinated soda solution of a strength such as is usually employed in milk plants for disinfecting purposes. The strips were then dried in air, which caused the surface to become quite dark. The milk in contact with the copper was boiled for one and one-half hours, and the following amounts of copper were dissolved per liter of milk:

	mgm.
Bright copper	5.35
Darkened copper	26.50

Experiment 4. This experiment was run at the same time in exactly the same way as experiment 3 except that the milk contained 18 per cent sugar. The following results were obtained.

	mgm.
Bright copper	6.45
Darkened copper	20.60

These experiments show the ease with which copper dissolves from a corroded surface of copper as compared with a well polished surface.

The fact that air increases the solvent power of milk is no doubt related to the fact that copper dissolves from a surface coated with oxide more readily than from a polished surface. It can always be noticed that where milk is heated in a copper vessel there is very soon formed a streak of dark copper near the surface of the milk. By covering this with milk it is soon dis-

solved and a new ring forms again at the surface. It is entirely probable, therefore, that air assists in the solution of copper in milk by continually corroding the surface, thus rendering the copper more readily dissolved.

Relation of carbon dioxide to the solvent power of milk

Generally carbon dioxide is considered to increase the dissolving power of solutions. This gas is known to increase the solubility of copper in water and in some salt solutions though it greatly decreases the solubility of copper in ammonium chloride solution (14). Milk contains a considerable proportion of this gas, so the following experiments were carried out to determine if this might be a factor in the reaction.

Experiment 5. Four thousand cubic centimeters of milk was heated and by applying vacuum and agitation the gases were removed as much as possible. This was divided and cooled. Half of it was saturated with carbon dioxide by bubbling the gas for a long time. The two portions were heated with copper strips at 140°F. for one hour. Milligrams of copper dissolved per liter were as follows:

	mgm.
Saturated with carbon dioxide	4.80
Not so treated	7.65

Experiment 6. Two portions of milk were heated at 140° for one hour with copper. In one case carbon dioxide gas was bubbled through the milk during the heating period and in the other case nitrogen gas. The latter was taken as a check so that approximately the same degree of agitation could be effected in the two cases; the solvent power of the milk should not be changed by the nitrogen. Following are the amounts of copper dissolved in milligrams per liter.

	mgm.
Passing carbon dioxide	9.05
Passing nitrogen	9.70

Experiment 7. On another occasion two 2000-cc. portions of milk were boiled with copper strips for two and one-half hours.

In one case carbon dioxide was bubbled through the milk throughout the heating period, and in the other case no gas used. Following are the results in terms of milligrams copper per 1000 cc. of milk.

	mgm.
Passing carbon dioxide	17.5
No gas	17.9

These experiments show beyond doubt that carbon dioxide has no influence on the solvent power of milk. The milk used in experiment 7 showed a much greater solvent action on copper than most of the samples used, there was apparently no explanation for this variation. However, the comparison of the check against the portion with carbon dioxide is very similar to the results in experiment 6.

Effect of amount of surface exposed and the time of contact with the metal

Experiment 8. A series of 3 samples were run as follows:

Sample 1— 70 square inches of copper, two and one-half hours boiling.
Sample 2—140 square inches of copper, two and one-half hours boiling.
Sample 3—140 square inches of copper, one and one-quarter hours boiling.

The quantities of copper dissolved were:

Sample 1—1.45 mgm. per liter.
Sample 2—4.10 mgm. per liter.
Sample 3—2.95 mgm. per liter.

On account of the wide limits of error in these results no conclusions should be drawn quantitatively. However, it is evident that the more surface of copper exposed and the greater the time of exposure the more copper will be dissolved, and if there is a limit to the amount of copper the milk will dissolve it has not been found in this experiment.

Effect of temperature on the amount of copper dissolved

Experiment 9. Determinations were made at three temperatures. In each the milk was in contact with the copper for

two and one-half hours, the strips being dropped in after the temperature of the milk was brought to the desired point. The following were the quantities of copper in milligrams dissolved per liter of milk:

	mgm.
Room temperature	6.00
145°F	14.15
Boiling	4.45

Experiment 10. The results of experiment 9 seemed so extraordinary that another experiment was run in exactly the same way. The following results were obtained:

	mgm.
Room temperature	4.95
145°F	11.30
Boiling	3.85

Experiment 11. Still another run was made as in the two preceding experiments except that the temperatures of boiling and 145°F. only were used. Quantities of copper per liter were as follows:

	mgm.
At 145°F	16.25
Boiling	5.35

It is evident from these experiments that milk attacks copper much more readily at 145°F. than at boiling temperature and also that there is but little difference between the amount dissolved at room temperature and at boiling. In this connection it might be pointed out that Carnelley (16) has shown that copper dissolves in water and in some salt solutions less readily at boiling than at lower temperatures. Also Emery (15) found that the rate of solution of certain metals in fats was independent of the temperature.

On the other hand, it appears that the question is not quite so simple as this as will be shown in the next experiment.

Experiment 12. Four thousand cubic centimeters of milk was boiled for thirty minutes, cooled, and the water which was lost on evaporation was replaced. This was divided and through 2000 cc. air was bubbled for fifteen minutes. Both of these

portions were heated at 145° with copper for two and one-half hours and at the same time 2000 cc. of the same milk unboiled was heated with the same amount of copper for the same time and at the same temperature. The following results show the amounts of copper dissolved per liter of milk in milligrams:

	mgm.
Boiled, cooled and saturated with air	5.45
Boiled, cooled, no treatment	5.35
Not boiled	16.25

This experiment shows that by boiling the milk something is destroyed or transformed thus reducing the solvent power of the milk. It was at first thought that this might be explained on the basis of a removal of air by boiling, and that was the reason for introducing air into one of the boiled portions in the above experiment. However the results show that this would not explain the difference in activity between boiled and unboiled milk. Yet another experiment was carried out to surely prove the point:

Experiment 13. Four thousand cubic centimeters of milk which had been boiled for some time was cooled to 145°, divided, and air bubbled through half of it for one hour. Both portions were than heated with copper for two and one-half hours at 145°F. Amounts of copper dissolved per liter of milk were as follows:

	mgm.
Saturated with air	5.45
Check	5.60

Effect of the addition of sucrose on the solvent action of milk

In the manufacture of sweetened condensed milk there is ordinarily added to the milk in the hot wells 18 per cent sugar which solution is drawn into the vacuum pan for condensation.

Experiment 14. In sample 1 milk with no addition dissolved from smooth bright copper strips in one and one-half hours at boiling 5.35 mgm. copper per liter, while in the sample containing 18 per cent sucrose under the same conditions 6.45 mgm. of copper was dissolved. Again using copper strips which had

been darkened by immersion in chlorinated soda solution and drying in air, milk with no addition dissolved 26.5 mgm. copper per liter while milk with sugar dissolved 30.6 mgm.

The addition of sucrose to the milk in the manufacture of sweetened condensed milk increases but little the amount of copper dissolved.

Effect of the acidity of the milk on the amount of copper dissolved

Experiment 15. A sample of fresh milk with acidity of 0.16 per cent was allowed to act on copper at 140°F. for one hour when it was found that 5.45 mgm. copper was dissolved per liter, and the same milk allowed to stand in the laboratory until it reached 0.2 per cent acidity dissolved under the same conditions 6.55 mgm. copper.

Experiment 16. A portion of the same milk used in experiment 12 was allowed to stand at room temperature until the acidity had reached 0.216 per cent. (The original milk titrated 0.162.) This sample was then heated with copper at 145°F. for two and one-half hours. The amount of copper dissolved per 1000 cc. of milk was found to be 5.65 mgm.

From these experiments it must be concluded that slight increases in acidity of the milk do not greatly increase the amount of copper dissolved; in fact the amount of copper dissolved was actually reduced in the last experiment. Inasmuch as the acidity of the samples of milk in these experiments was much lower than would be found in very sour cream and buttermilk, conclusions should not be drawn from these results as to the behavior of those products.

Distribution of copper between the cream and the skim milk fractions

Experiment 17. Six thousand cubic centimeters of whole milk was heated with copper some air being passed into the milk at the same time in order that a considerable quantity of copper would be dissolved. Four thousand cubic centimeters of this was put through a hand separator and in this way there was obtained

875 grams of cream testing 20.2 per cent fat and 5.94 per cent solids not fat, and 3110 grams of skim milk testing 0.1 per cent fat and 9.2 per cent solids not fat. The total amounts of copper found were 27.5 mgm. in 2000 grams of whole milk; 7.8 mgm. in 875 grams cream and 27.8 mgm. in 3110 grams skim milk.

First of all, these results show that there was a loss of copper in the separator—4000 cc. of whole milk contained 55 mgm. copper, but in the cream and skim together there was found only 35.6 mgm. From this it would seem that a considerable part of the copper must have become insoluble and gone into the slime.

In order to make further comparisons some calculations were made from the above results as follows:

	CREAM	SKIM
	mgm.	mgm.
Copper per kilo of fraction	8.9	8.9
Copper per 100 grams of fat	4.4	894.0
Copper per 100 grams of solids not fat	15.0	9.7
Copper per kilo of water	12.0	9.9

From these calculations it is seen that the copper distributes itself between the cream and skim fractions in proportion to the weight of the fraction itself and quite closely to the distribution of the water. From this it would seem that the copper is merely dissolved in the water.

There is one point of certainty from these results—that the copper does not distribute itself with the fat and, therefore, is not dissolved in the fat as was assumed by Donauer (12). Similarly, it was shown by Rogers, Berg, Potteiger and Davis (2) that although excessive amounts of iron in cream affected the quality of butter made therefrom, yet most of the iron went into the buttermilk fraction. In order to have an agency acting upon fat it is not necessary to suppose that it dissolves in the fat, it may be dissolved in the moisture incorporated in the fat or be adsorbed at the surface of the fat globules. It has been found in this laboratory that upon separation of a quantity of milk most of the lipase is found in the skim milk.

Also, it has been pointed out by Beatty (17) that pancreatic lipase is "entirely insoluble in fats, fatty acids and solutions of fats in ether, yet it acts on these bodies."

On the other hand Watson has shown that copper does dissolve in certain oils (14). It is evident, therefore, that considerable work should be done along this line before conclusions can be drawn as to the agency in the milk most important in dissolving the metals.

Electrochemical relations between copper and tin

In the electrochemical series of elements copper is somewhat below tin, consequently tin replaces copper in solution, the latter plating out. There is the possibility, therefore, that milk with dissolved copper upon coming in contact with tin may lose some of the copper. Commercial condensed and evaporated milk in tin cans would thus in time become lower in copper content, also milk equipment with both copper and tin surfaces exposed to the milk will yield less copper to the milk than a copper surface alone. This effect is shown in the following experiments.

Experiment 18. Four thousand cubic centimeters of milk was boiled with copper in order to get as much of the metal in solution as possible. Half of this was then boiled for two and one-half hours with strips of tin. Amounts of copper per liter in milligrams were as follows:

	mgm.
Original half	33.9
Boiled with tin	28.4

Experiment 19. Two liters of milk was boiled with copper strips amounting to 140 square inches, the flask at the same time containing tin strips sufficient to give 80 square inches of surface. At the same time an equal quantity of the same milk was boiled with an equal amount of copper but without the tin. Copper dissolved per liter of milk was found to be as follows:

	mgm.
Without tin	17.9
With tin	6.7

The results of these two experiments show what was postulated from theoretical considerations: (*a*) That copper once dissolved in the milk may plate out on any tin surface with which it may later come in contact and (*b*) that where milk is exposed to surfaces of tin and copper together, less copper is dissolved than where there is the same exposure of copper without the tin. The latter condition would be found in copper equipment plated with tin but from which the tin had been worn in places exposing the copper surface. Under such conditions it would be expected that very little copper would be dissolved but through the same electrochemical effect the tin would be dissolved even more rapidly than from a tin surface alone.

Copper in commercial samples of condensed and evaporated milk

Copper was determined in 10 samples of sweetened and 6 of evaporated milk representing 9 brands. The amount of copper per kilo varied from 2.4 to 4.8 mgm. Average for all samples was 3.7. Taking 0.5 mgm. per liter as the amount of copper naturally present in cow's milk it is evident that the milk had added considerable quantities of copper in the process of manufacture. However, as has been demonstrated in the preceding experiment it is entirely possible (and judging from earlier experiments it would seem probable) that more copper had dissolved in the milk during manufacture, then, later in contact with the tin of the container some of the metal was lost from solution through electrochemical action.

SUMMARY AND CONCLUSIONS

1. The unfavorable effect of the presence of copper and other metals in milk and its products has been thoroughly demonstrated by many previous investigators.

2. Since the equipment used in most dairy manufacturing operations is made of copper, it is important to know something of the conditions under which the copper dissolves in the milk and to learn, if possible, how it can be reduced to a minimum.

3. The presence of air and oxygen was here found to increase enormously the amount of copper dissolved by milk. Therefore, open pasteurizers, coolers, and holding tanks would be expected to yield much more copper than vacuum pans, and it would be much more important to have these of non-copper material.

4. Copper corroded with an oxide surface yields much more of the metal to the milk than smooth bright copper. It is particularly important to keep such equipment clean and well polished. Since the chlorine disinfectants such as chlorinated soda are usually active in corroding copper surfaces, their use should be avoided on copper hot wells and vacuum pans.

5. Carbon dioxide does not influence the dissolving power of the milk.

6. The amount of copper taken up by the milk increases with the amount of copper surface exposed and with the time of exposure.

7. About the same amount of copper is dissolved in the milk at room temperature as at boiling; at 145°F. considerably more copper is dissolved than at either. Therefore, in the manufacture of condensed and evaporated milk where copper hot wells are employed it is important to bring the temperature of the milk to boiling as rapidly as possible.

8. Inasmuch as milk once boiled dissolves about the same amount of copper at 145°F. as at boiling temperature, some transformation or loss of the agency which attacks the copper is indicated.

At the present time no conclusions can be drawn as to the cause of this phenomenon. It has only been shown that replacing the air in boiled and cooled milk does not reëstablish the same solvent power exhibited at 145°F. in unboiled milk.

9. The presence of 18 per cent sugar does not increase more than a little the amount of copper dissolved by milk. The amount of copper dissolved from pans and hot wells in the manufacture of sweetened condensed milk is not, therefore, much greater than in other manufacturing operations.

10. Milk slightly sour dissolves but little more copper than normal milk.

11. On passing milk containing copper through a separator, the metal distributes itself between the cream and skim milk fractions approximately in proportion to the water. It would seem, therefore, that it is dissolved in the water. The results show conclusively that the copper does not go with the fat, and is, therefore, not dissolved in the fat.

12. Analyses of commercial samples of condensed and evaporated milk indicate that copper is taken up in considerable quantities in the manufacture of these products.

13. From theoretical considerations and from experimental results it was shown that copper may be lost from milk to tin when it comes in contact with this metal, and also that less copper is dissolved when the milk is exposed to surfaces of copper and tin together. Consequently, it would be expected that condensed and evaporated milk would lose some of its copper to the tin of the container and consequently a can purchased on the market would show somewhat less copper in solution than was present at the time of manufacture. Also a copper cooler or pasteurizer imperfectly tinned would yield less copper to solution than if the milk were exposed to the same surface of copper without the tin.

On the basis of the same theoretical considerations the tin should dissolve in the milk much more rapidly when in contact with the copper, which would in part account for the rapid wearing of tin from such equipment. The latter point however, is not supported by any experimental evidence in this paper, no determinations for tin having been made in any samples.

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SOME FACTORS INFLUENCING QUALITY IN GELATIN AND THE USE OF THE FERMENTATION TEST AS AN INDEX OF BACTERIAL CONTAMINATION

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The consideration of quality of gelatin involves two large general questions. First, that the gelatin be free from metals and other substances injurious to health. Second, that it have a low bacterial content, free from undesirable organisms, a clear color, desirable odor, pleasant taste, low acidity and high jelly strength or water absorbing quality. The first of these questions is well taken care of by the Federal and State laws and are such that it is relatively easy for the gelatin manufacturer to comply with. It is but recently that much attention has been paid to the second question and interest is increasing, especially in regard to bacterial content and jellying powers. The second question is what is to be considered in this paper.

Fifteen samples of gelatin were secured in 5-pound lots from gelatin manufacturers, the object of the purchase was unknown to them. The total bacterial count was determined upon standard nutrient agar plus 1 per cent of lactose. The colon count determined upon the medium recommended by Ayers and Rupp. The fermentation test was run parallel with the plates and made in the following manner: 10 grams of gelatin were weighed aseptically into 100 cc. of sterile distilled water containing 1 gram of lactose. The temperature used to hasten the dissolving of the gelatin was 50°C., with sterile pipettes transferred to sterile tubes allowed to solidify and incubate at 28°C. for eighteen hours and 20° for thirty-six hours. The plates were incubated at 25°C. for thirty-six hours. The work was done in triplicate and repeated twice and the average results obtained shown in table 1.

From the foregoing it can be concluded that the fermentation test can give the ice cream maker or user of gelatin an index of the bacterial contamination of the gelatin under consideration. Liquification in some degree showed in all samples where the bacterial content was greater than 5000 and gas bubbles in all cases where the colon content exceeded 100. It is hoped in

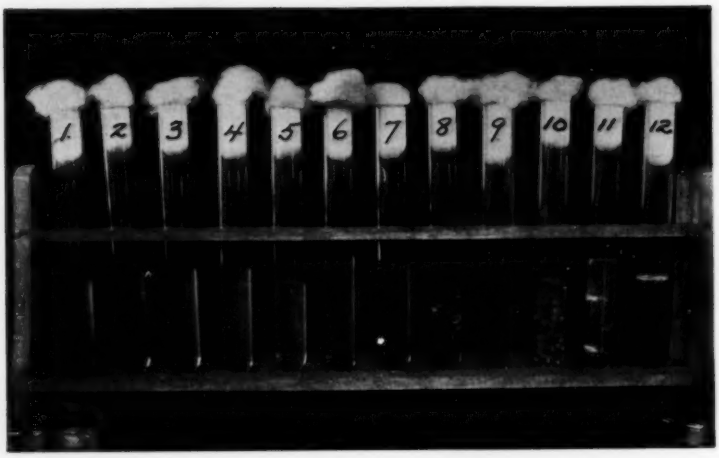
TABLE 1

GELATIN NUMBER	TOTAL BACTERIA	COLON COUNT	FERMENTATION REACTION	
			Liquification	Gas
1	750,000	200,000	++++	++++
2	1,500	Less than 100	−	−
3	2,600	Less than 100	−	−
4	5,000	Less than 100	−	−
5	200	Less than 100	−	−
6	100	Less than 100	−	−
7	5,000,000	600,000	++++	++++
8	2,000,000	750,000	++	++++
9	10,000	400	+−	+
10	450,000	50,000	++	++++
11	500,000	2,000	+	+++
12	60,000,000	35,000,000	++++	++++
13	500	Less than 100	−	−
14	500	Less than 100	−	−
15	70,000	4,200	+	++

further studies to determine what the various steps in gelatin manufacture affect the total bacterial count and colon content and to study if high bacterial content causes any lessening of the value of gelatin.

JELL STRENGTH AS A FACTOR IN DETERMINING QUALITY

It is believed that the jell strength of gelatin or its water absorptive properties are of importance, in the standing up powers of ice cream. Eleven samples of gelatin were tested for jell strength in the following method: (1) By preparing definite strength solutions of gelatins, viz., 1 to 1.5 to 2 per cent and so on and allowing these solutions to remain for 12 to 16 hours at 20°C.; (2) by preparing a 10 per cent solution and pouring it out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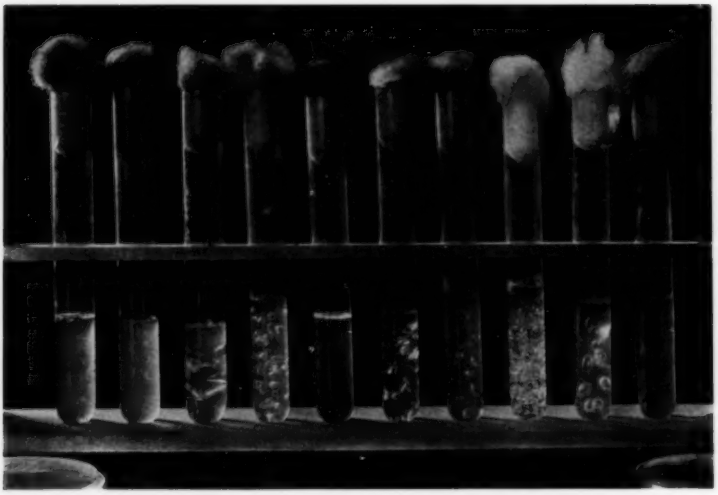

on Petri dishes, allowing them to remain five hours at 20°C. The method of determining jell strength by method 1 was by inverting the tube and in method 2 by pressure of the thumb. Method 2 was found unsatisfactory in that there was too great a chance for error upon the part of the operator.

By referring to table 1, notice that gelatins 2, 3, 4, 5 and 6 were low in bacterial content. By the use of the thumb test, the operator could not detect a difference of less than 2 per cent in jell strength. It has been found that the second method or thumb test is used by ice cream men to determine jell strength quite extensively but from this work is not to be recommended.

TABLE 2

GELATIN NUMBER	PER CENT GELATIN REQUIRED TO JELL IN DISTILLED WATER AT 20° FOR SIXTEEN HOURS
2	2.5
3	2.5
4	1.5
5	1.5
6	2.0
7	20.0
8	5.0
9	5.0
10	5.0
11	4.5
12	4.0

The range of hydrogen-ion concentration in the 15 samples of gelatin varied from 4.86 to 7.33 measured electrometrically and titrable acidity from zero to 8.0 cc. $\frac{N}{10}$ NaOH per 25 cc. of a 10 per cent solution of gelatin using phenophthalein as an indicator, but the pH or titrable acidity showed no effect upon bacterial count or jell strength.

ODOR AND TASTE AS A MEASURE OF QUALITY

The odor and taste were determined in 10 per cent solutions and it was found that gelatin 12 which had such a high bacterial content was but very little off in flavor and odor, while gelatin 9 was badly off in flavor and odor but showed a relatively low bacterial

count. While it is desirable to have good flavor and odor upon gelatin believe that too much emphasis can be put on this factor relative to its value.

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THE BACTERIAL CONTENT OF SOME KANSAS ICE CREAM

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INTRODUCTION

For the past three years the Dairy Department of the Kansas State Agricultural College has conducted an ice cream scoring contest, open to all manufacturers of ice cream, marketing their product in Kansas. A few of the samples entered were especially prepared and represented the best product of the plant. The majority of the manufacturers, however, submitted samples that represented their regular product as sold on the market. A few of the contestants were manufacturers residing outside the state, but were marketing at least a part of their product in Kansas.

The score card used in these contests allowed a perfect score of 20 points for ice cream containing not more than 20,000 bacteria per gram. The bacterial analyses were made by the Bacteriology Department of the Kansas State Agricultural College and the data thus obtained afforded an opportunity to study the bacterial content of ice cream as it is sold in the state of Kansas.

METHOD OF ANALYSIS

A $\frac{1}{4}$-inch layer of ice cream was discarded from the surface of each container in order to eliminate surface contamination. The sample for bacteriological analysis was then taken with a sterile butter sampler. Two cores were removed from the entire depth of the ice cream; one from the center and one near the edge of the can. These cores were placed in a sterile bottle and the bottle submerged in water at 45°C. for five to ten minutes until the ice cream had melted. A gravimetric sample was obtained by adding 10 grams of the melted ice cream directly in 90 cc. of

sterile, normal saline. From this, appropriate dilutions were made.

The plates were made and incubated according to the "Standard Methods for Bacteriological Examination of Milk," as recommended by the American Public Health Association in 1921. All determinations are on a gravimetric basis and therefore, represent the number of bacteria per gram of ice cream as determined by the official plate count.

RESULTS OBTAINED

Table 1 shows the bacterial counts, arranged in the order of the number of bacteria per gram, of all the samples analyzed in the three contests.

The samples numbered 1 to 39 inclusive were from the 1922 contest; those number 40 to 67 inclusive from the 1921 contest, and those numbered 68 to 115 inclusive from the 1923 contest.[1] The average number of bacteria per gram in all the samples was 1,895,000. The average for the 1921 contest (28 samples) was 1,383,428 per gram. The average for the 1922 contest (39 samples) was 1, 992, 461 per gram. The average for the 1923 contest (48 samples) was 2,114,239 per gram.

The following observations may be made from the table.

10 samples or	8.7 per cent contain	5,000 or less bacteria per gram
22 samples or	19.1 per cent contain	20,000 or less bacteria per gram
42 samples or	36.5 per cent contain	50,000 or less bacteria per gram
57 samples or	49.6 per cent contain	100,000 or less bacteria per gram
75 samples or	65.2 per cent contain	200,000 or less bacteria per gram
86 samples or	74.8 per cent contain	300,000 or less bacteria per gram
90 samples or	78.3 per cent contain	500,000 or less bacteria per gram
98 samples or	85.2 per cent contain	1,000,000 or less bacteria per gram
17 samples or	14.8 per cent contain	more than 1,000,000 bacteria per gram

It will be observed that only 22 or 19.1 per cent of the samples could be given a perfect score for bacterial content according to the score card. It may also be noted that only 14, or 12.1 per cent, of the samples contained more than the *average* number of bacteria.

[1] The results for the year 1921 were obtained by Prof. O. W. Hunter.

The counts for these 14 samples were so high that it raised the average for the group to nearly 2,000,000 per gram. The average count in such a class of variables is not of much significance because of the irregularity introduced by these few individuals. The middle class in such a set of variables is perhaps a better index than is the average count. Since there are 115 samples in this series, the middle class would be between the fifty-seventh and fifty-eighth samples. It will be noted that the bacterial count of this class would be close to 100,000 per gram.

The state laws of Kansas require that all materials used in the manufacture of ice cream be pasteurized at 145°F. for thirty minutes. The evidence here presented indicates that it is possible, under Kansas conditions to place on the market a product having a consistently low bacterial count.

FACTORS INFLUENCING BACTERIAL CONTENT OF ICE CREAM

Products. There are several factors which must be taken into consideration in the manufacture of ice cream having a low bacterial content. The products used in making the mix should be of high quality and contain a relatively small number of organisms. Gelatin, skim milk powder, butter, cream, and milk are usually the most important factors contributing to a high bacterial content in the raw mix. If these products are of poor quality and contain large numbers of bacteria, the mix is sure to have a high bacterial count before pasteurization. This is especially true of the cream, which is frequently found to contain several millions of organisms per gram. Some manufacturers are obliged to buy cream from small producers who do not market their product every day. This usually results in the use of cream having a very high bacterial count, which in turn will affect the initial count of the mix and also the final count of the ice cream. For example, if the raw mix contains 30,000,000 bacteria per gram as a result of using a poor quality of raw product, the bacterial count after pasteurization is certain to be high. With 99 per cent efficiency of pasteurization there would remain 300,000 bacteria per gram. The only remedy for this condition is to purchase raw materials of better quality. If the ice cream is not made from

clean wholesome products, it will be manifested in the high bacterial count of the finished product.

Pasteurization. The efficiency of pasteurization is perhaps the most important factor in controlling the bacterial content of ice cream. If the mix is held at 145°F. for not less than thirty minutes it is reasonable to expect 99 per cent efficiency in the destruction of organisms. With a mix containing 5,000,000 bacteria per gram, 99 per cent reduction would leave 50,000 bacteria per gram after pasteurization. On the other hand if the time is cut down to twenty minutes, about 75 per cent efficiency of pasteurization would be the result. With this hypothesis there would remain 1,125,000 bacteria per gram after pasteurization instead of 50,000. The ice cream from such a mix is destined to have a high bacterial count and will score 18 to 20 points lower than a properly pasteurized product. This loss of quality is due to a saving of ten minutes of time. In many instances the high bacterial content of ice cream may be traced directly to reduced time of pasteurization by the manufacturer. After the mix leaves the pasteurizer there is slight increase in the number of bacteria as a result of homogenizing. This is probably due to the breaking up of clumps of bacteria.

Ageing. Unpublished data from experimental work, carried on at this station under plant conditions, shows no material increase during the ageing process, when the temperature conditions were properly controlled. By keeping the temperature at 40°F. or below, the growth of bacteria can be checked very effectively. Failure to control the temperature during this process is very frequently the cause for high bacterial counts in ice cream. A difference of only a few degrees may mean a million more organisms per gram in the finished ice cream.

Freezing. During the freezing process there is sometimes observed a slight increase in the number of organisms. This is frequently within the limits of experimental error and may not be detected. Such an increase in the number of organisms would probably be due to the breaking up of clumps of bacteria as a result of the whipping of the mix, or to contamination from the freezer.

Storage. From the time the ice cream enters the hardening room until it is consumed there is a very slight, gradual reduction in the number of organisms due to the destruction of the types that are unable to withstand the low temperature. In general it may be said that under properly controlled conditions, there will be a slight increase in the bacterial content of the finished product, over that of the mix as it leaves the pasteurizer. This increase, however, is too small to explain some of the high counts reported in table 1.

Utensils. Another factor that should not be onverlooked is the contamination of the mix from the utensils. Ice cream mix comes in contact with many utensils during the process of manufacture. If the cans, vats, pipe lines, and freezers are not properly steamed, they may be a very important source of contamination. To cite a concrete example from a Kansas plant, an ice cream mix before being placed in the freezer had a bacterial count of 26,000 per gram. After freezing it contained 625,000 per gram. Some of this increase may have been due to the breaking up of clumps of bacteria, but most of it was probably due to a poorly washed freezer.

SIGNIFICANCE OF THE BACTERIAL COUNT OF ICE CREAM

The bacterial count of ice cream is perhaps a better index to the conditions surrounding its production than is the count on any other dairy product. This is especially true of milk. Even though milk is produced under ideal conditions, if it is held at favorable temperatures the bacteria will grow so rapidly that there may be millions of organisms present in a few hours. The bacterial count of milk as it is placed on the market, therefore, may not be directly proportional to the sanitary conditions surrounding its production. The development of organisms in ice cream subsequent to its manufacture is practically eliminated as a result of the low temperature at which it is held. A bacterial analysis made at any time should not greatly exceed the initial count when the ice cream left the freezer. This fact renders the determination of total numbers of bacteria in ice cream particularly valuable, since it reveals the condition of the product when

TABLE 1

The bacterial count of 115 samples of Kansas ice cream

LINE NUMBER	SAMPLE NUMBER	OFFICIAL PLATE COUNT PER GRAM OF ICE CREAM	LINE NUMBER	SAMPLE NUMBER	OFFICIAL PLATE COUNT PER GRAM OF ICE CREAM	LINE NUMBER	SAMPLE NUMBER	OFFICIAL PLATE COUNT PER GRAM OF ICE CREAM
1	115	1,500	39	65	45,000	77	27	215,000
2	104	3,000	40	93	46,000	78	111	220,000
3	113	3,000	41	5	49,000	79	48	225,000
4	35	4,000	42	21	49,000	80	33	228,000
5	112	4,000	43	87	52,000	81	83	240,000
6	40	5,000	44	91	52,000	82	66	250,000
7	42	5,000	45	106	53,000	83	39	262,000
8	62	5,000	46	84	67,000	84	7	284,000
9	79	5,000	47	4	74,000	85	34	300,000
10	100	5,000	48	86	75,000	86	49	300,000
11	89	6,000	49	16	77,000	87	38	343,000
12	26	7,000	50	98	80,000	88	45	350,000
13	32	7,000	51	99	80,000	89	43	500,000
14	64	8,000	52	9	85,000	90	52	500,000
15	13	14,000	53	20	86,000	91	14	600,000
16	102	14,000	54	12	87,000	92	53	600,000
17	107	14,000	55	96	90,000	93	82	620,000
18	2	15,000	56	24	100,000	94	76	660,000
19	10	15,000	57	41	100,000	95	22	700,000
20	101	16,000	58	17	109,000	96	67	700,000
21	55	20,000	59	92	110,000	97	105	720,000
22	94	20,000	60	110	110,000	98	60	900,000
23	41	23,000	61	8	122,000	99	69	1,100,000
24	114	23,000	62	103	125,000	100	108	1,300,000
25	23	25,000	63	68	135,000	101	81	1,600,000
26	44	25,000	64	78	145,000	102	3	2,000,000
27	47	25,000	65	15	150,000	103	57	3,000,000
28	11	29,000	66	59	150,000	104	19	4,000,000
29	95	30,000	67	75	150,000	105	80	4,000,000
30	28	33,000	68	90	155,000	106	73	4,500,000
31	37	34,000	69	31	188,000	107	109	5,000,000
32	36	36,000	70	25	200,000	108	61	10,000,000
33	85	36,000	71	50	200,000	109	71	16,000,000
34	88	37,000	72	51	200,000	110	72	16,500,000
35	6	38,000	73	54	200,000	111	18	18,000,000
36	97	40,000	74	56	200,000	112	63	20,000,000
37	1	41,000	75	58	200,000	113	29	22,000,000
38	70	41,000	76	77	200,000	114	30	27,000,000
						115	74	47,000,000

it was produced. If carelessness prevails at any point in the production of ice cream, or if it is made from materials of poor quality, the finished product is almost certain to have a high bacterial count.

The 17 samples reported in table 1, having more than 1,000,000 bacteria per gram, certainly were not produced under carefully controlled conditions. At some point in the manufacturing process, the bacterial growth was not checked. The bacterial count does not reveal what was responsible, but it does indicate that carelessness has prevailed in one or more points in the manufacturing process. This fact alone should prohibit the sale of such a product.

The increasing popularity of ice cream; its change of status from that of a delicacy to that of a staple human food; and its large use by children and by the sick, makes it imperative that the conditions surrounding its production be controlled by legislation. The establishment of legal standards limiting the bacterial content of dairy products, is an effort to protect the consumer against the use of foods that are not properly handled. It does not necessarily mean that milk, ice cream, etc., that contain more than a certain number of organisms are dangerous to use. It does mean, that if the food contains more bacteria than the legal standard, carelessness has prevailed at some point in the production or marketing. This is the factor that the legal standard seeks to exclude.

It is not the purpose of this paper to suggest a legal standard for ice cream. The establishment of a standard should be made only after a thorough study of the manufacturing process under commercial plant conditions. Such a study is now in progress at the Kansas Experiment Station. Whatever the standard may be, it should be fair to the manufacturer and yet necessitate careful handling in every operation. It should make necessary the use of clean, wholesome products of good quality and low bacterial content. The standard should be low enough to exclude ice cream made from products that have not been efficiently pasteurized. It should make it necessary to control the temperature of the mix during the ageing process, and to use utensils that have been thor-

oughly cleaned and steamed. A legal standard should be rigid enough to prevent laxity in any of these important processes of manufacture. It should make ice cream a safe food for all, but especially for children and for the sick.

Although the primary purpose of a standard for ice cream should be to protect the consumer, it is equally important to make it reasonable for the manufacturer. If the minimum number of bacteria was so placed that it would be impossible to comply with it, it would be disregarded and could not be enforced. It is fair, however, to ask the ice cream manufacturer to use clean products, clean equipment and to control every operation in the manufacture of this important food. Since the bacterial count affords an index to the care used in manufacturing, it makes a good basis for legislative control of the manufacture of ice cream. By the adoption of bacterial standards the manufacturer would be obliged to produce a clean, safe, and healthful food.

From the data given in table 1, it will be seen that half of the manufacturers submitted samples containing less than 100,000 bacteria per gram. From this, it does not seem unreasonable to assume that the other half could do likewise. Assuming these samples to be representative, it would not seem unreasonable from the standpoint of fairness to the manufacturer, to demand ice cream with a bacterial count of less than 100,000 per gram. However, if further investigation shows that ice cream can be produced under careless conditions and still contain fewer than 100,000 bacteria per gram, the figure should be correspondingly lowered. On the other hand, if it is found that ice cream made from clean products and produced under well controlled plant conditions may contain as high as 200,000 or 300,000 bacteria per gram, the standard should be adjusted accordingly.

SUMMARY

The bacteriological analyses of 115 samples of ice cream are submitted. The bacterial counts range from 1500 per gram to 47,000,000 per gram. The average of all the samples is 1,895,000 per gram. However, the average count on a series of samples may not always give a figure that is representative of the whole

class. In this group of variables, the middle class is shown to be a more representative figure than the average.

Three-fourths of the samples contained less than 300,000 bacteria per gram, and half of them less than 100,000 per gram. An analysis of the various factors influencing the bacterial count of ice cream indicates that the effeciency of pasteurization and control of the temperature during the ripening process are the most important factors in producing ice cream with a low bacterial count.

The inhibition of multiplication of the organisms as a result of the low temperature at which the finished product is held, makes the bacterial count of ice cream a good index to the conditions surrounding its production.

The establishment of legal standards governing the bacterial content of ice cream is briefly discussed, but no effort is made to suggest a standard from these results. However, the high per cent of samples containing 100,000 bacteria or less per gram, indicates that this figure would not be unfair to the Kansas producer.

FACTORS INFLUENCING TWO-DAY OFFICIAL BUTTER-FAT TESTS OF COWS[1]

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In official cow testing work the various breed associations base the production of dairy cattle very largely on the records of a two-day test for each month throughout the year. It is important therefore to investigate the factors which may influence the two-day test. A study of these factors shows that some things affecting the test of the cow are under the control of the man in charge of the cow and some things are not under his control. Only a few of these factors can be considered in this paper.

I. FACTORS NOT UNDER CONTROL OF OWNER[2]

1. Seasonal variations. Regardless of all other factors there seems to be a variation in the average test of a cow from month to month. This is shown in table 1.

These figures are based on the averages of two-day Register of Merit Tests of Jersey cows in Tennessee. This table shows that the lowest test for the year is in July with an average of 4.95 per cent and that there is a gradual increase from this to 6.15 per cent for November, the highest month of the year. From November there seems to be a tendency toward a decrease to July. This shows a seasonal variation of 1.23 per cent from July, the lowest month, to November, the highest month. From July to November the increase in test is at the rate of 0.3 per

[1] Presented at the meeting of the Southern Division, American Dairy Science Association at Memphis, Tennessee, February 6, 1923.

[2] These tabulations were made by H. R. Love, senior student specializing in dairying, University of Tennessee, 1921–1922.

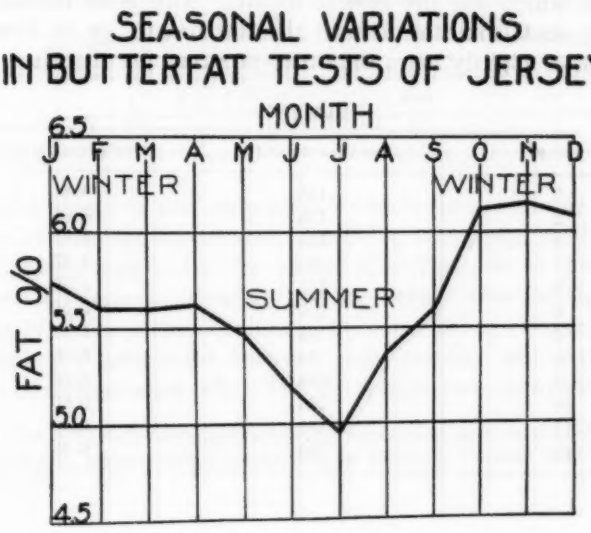
TABLE 1

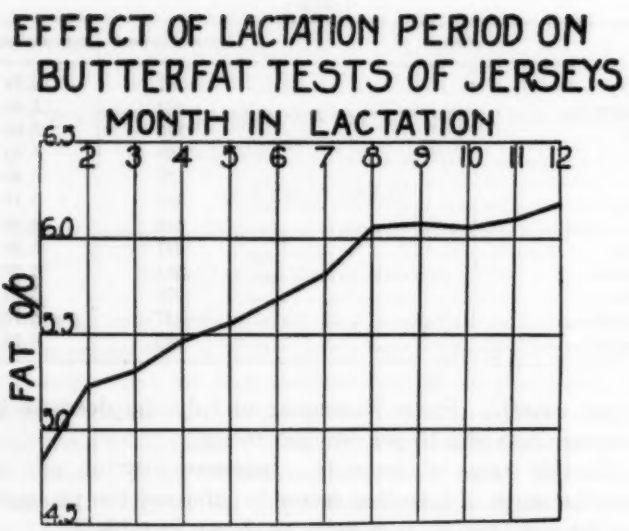
MONTH	NUMBER OF COWS	PERCENTAGE FAT
January	147	5.74
February	284	5.60
March	343	5.60
April	138	5.62
May	137	5.46
June	339	5.18
July	136	4.95
August	347	5.35
September	364	5.59
October	277	6.11
November	137	6.15
December	265	6.08

cent per month. From November to July the decrease it at the average rate of 0.15 per cent per month.

2. Monthly stage of lactation. Independently of all other factors the stage of lactation seems to influence the per cent of butter fat from month to month, as shown in table 2.

These records are based on the two-day Register of Merit records of Jerseys in Tennessee. The lowest test for the year was





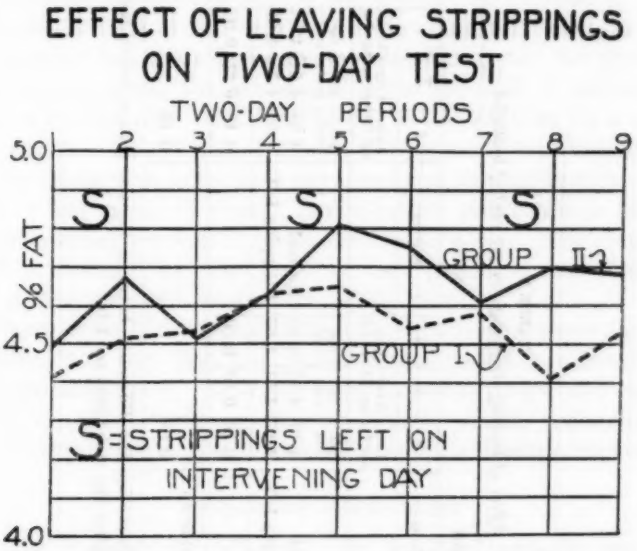
4.84 per cent the first month of lactation. There was a very gradual increase from this to 6.13 per cent the last month of lactation which was the twelfth month. This is an increase of 1.34 per cent from the first to the last month, or an average variation of slightly more than 0.11 per cent per month.

TABLE 2

MONTH	NUMBER OF COWS	PERCENTAGE OF FAT
1	154	4.84
2	154	5.23
3	154	5.31
4	154	5.47
5	154	5.56
6	154	5.69
7	154	5.82
8	154	6.06
9	154	6.08
10	154	6.06
11	151	6.10
12	143	6.18

II. FACTORS UNDER THE CONTROL OF OWNER[3]

1. Effect of leaving strippings in the udder on the following two-day test. Twenty-two cows were used in the experiment which covered a period of twenty-three consecutive days. The cows were divided into two groups of equal number and with an equal number of Jerseys and Holsteins in each group. Group I was used as a check for Group II.



The object of this experiment[3] was to determine the effect on official cow testing records of leaving strippings in the udder. Strippings were left in the udders of all the cows in group II on three different occasions at wide intervals. One-fourth approximately of the normal amount of milk was left as strippings. One whole day intervened between each two-day test period when the strippings were left. The strippings were always left at the

[3] The laboratory investigations in this experiment were conducted by Ben P. Hazlewood, senior student specializing in dairying, University of Tennessee, 1922–1923.

TABLE 3

Effect of leaving strippings on per cent of butterfat

Stripping trial	FIRST			SECOND				THIRD				
Two-day testing periods	1	Milking	2	3	4	Milking	5	6	7	Milking	8	9
	Average fat		Average fat	Average fat	Average fat		Average fat	Average fat	Average fat		Average fat	Average fat
	per cent		*per cent*	*per cent*	*per cent*		*per cent*	*per cent*	*per cent*		*per cent*	*per cent*
Group I	4.41	Normal	4.51	4.53	4.63	Normal	4.65	4.54	4.58	Normal	4.41	4.53
Group II	4.49	Stripping left	4.67	4.51	4.63	Stripping left	4.81	4.75	4.61	Stripping left	4.70	4.68
Difference	0.08		0.16	0.02	0.00		0.16	0.21	0.03		0.29	0.15
Increase of Group II apparently due to leaving strippings*			0.08				0.16				0.26	

* This figure is obtained by subtracting the difference between the two groups before the stripping period from the difference between the two groups after the strippings are left.

evening milking. The cows were milked twice daily. The experiment started January 3, with p.m. milking and ended January 25 with the a.m. milking. There were fifteen milking periods between the first and second trials on which strippings were left, and thirteen milkings between the second and third trials on which strippings were left.

In considering the effects of leaving strippings in the udder it is necessary to consider the cow as the unit in determining the average per cent of fat for the group. In calculating the average per cent of fat for a group the average is taken of the per cents of fat of the individual cows. This is not the method used in calculating the per cent of fat in the milk of individual cows when the total milk is divided into the total fat for a two-day period. The object of official testing work is to determine the production of individual cows and not the production of a herd or any group of cows. The monthly production is based on the average per cent of fat of the two-day test. The average milk production for the two-day test period is not used in calculating the milk production for the month.

There are so many factors influencing the test of a cow that it is difficult to say that any two-day test period is normal for that particular cow. It is necessary therefore to use as a check on the experiment a group of cows handled normally and compare the records of these with the group in which strippings are left.

RESULTS OF EXPERIMENT

Table 3 shows the effect on the two-day butterfat test of leaving strippings in the udder. In the first trial group II, in which strippings were left, made an average increase in fat of 0.08 per cent over group I, which was milked in a normal manner. In the second trial group II increased 0.16 per cent, and in the third trial 0.26 per cent.

Both groups averaged approximately the same per cent of butterfat for the first two-day test period. Group II increased in average per cent of butterfat more rapidly after strippings were left than group I even though the latter group made a slight increase. At the fourth two-day test period the two

groups again tested the same in per cent of butterfat. After strippings were left in the second trial group II made an increase in average per cent of fat of 0.18 while group I made an increase of only 0.02 per cent. The group in which strippings were left increased 0.16 per cent fat more than did the other group. Group II remained high in per cent of butterfat for a period of four days but on the seventh two-day test period the two groups tested approximately the same again. In the third trial group II increased 0.26 per cent more than group I and remained higher for a period of four days.

SUMMARY

A preliminary report of these experiments indicate the following:

1. A great many factors may influence the per cent of fat in cows milk.

2. Both the season of the year and the period of lactation cause a variation in the per cent of butterfat, the highest tests occruring, on the average, in the winter months and the latter months of the lactation period. The lowest tests occur on the average in the summer months and the first month of the lactation period.

3. Leaving one-fourth of the normal amount of milk as strippings in the udder of a cow apparently caused an increase in the per cent of butterfat in the milk of some cows, but the effect seemed to last over several milkings so that a single preliminary milking would not prevent the leaving of strippings at a milking previous to the preliminary milking.

A SCREEN USED IN PHOTOGRAPHING ANIMALS

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About six years ago the writer planned and constructed the device here described, in which to photograph cattle used in experiments. A considerable number of persons have been interested in it and the suggestion has been made that a description of it be published in some scientific journal. The writer finds it a very convenient piece of apparatus and this description is presented with the hope that it may be of use to others.

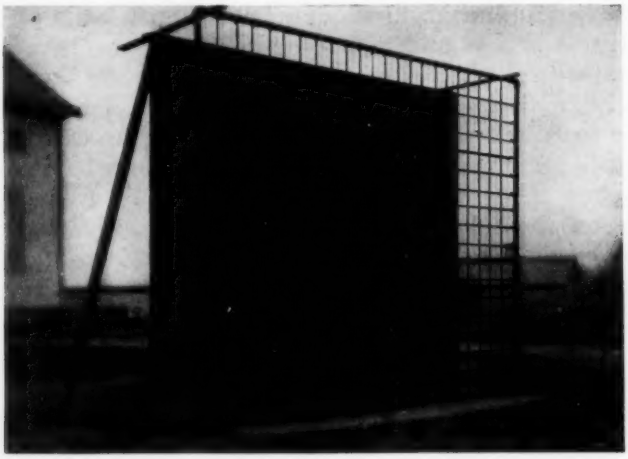
The one shown in the cuts consists of a screen, a platform and a background. The screen is constructed as follows: A rectangular frame 9 by 12 feet is made of 2-inch pipe. Holes large enough for a no. 9 wire are drilled through the frame at intervals of 6 inches. Vertical and horizontal wires are passed through these holes and stretched to form a screen with 6 inches mesh. It is important that the sides and ends of the frame be held rigidly while the wires are being stretched and secured. The wires should be brazed or electric welded at most of the points where they cross, in order to prevent their becoming slack and slipping out of place. The writer attempted to solder them but solder does not hold well. The lower horizontal wire should be placed so that the distance from it to the platform on which the frame rests and on which the animal stands shall be just the same as the space between the other wires.

The platform is 4 by 12 feet and consists of planks spiked to 2 by 4 inch pieces, the two end pieces extending about 4 feet to the rear for attaching the braces of the background.

The background should be as long as or longer than the screen. It is erected at the rear of the platform and consists of matched flooring on 2 by 4 inch studding. This would better have a

canvas stretched over it as in the photographs the wire lines may be confused with the crevices between the boards.

Two strips are attached to the top of the screen frame and pass back over the top of the background. Holes are bored through these strips at intervals and pins are passed through these holes into holes bored into the top of the background. This permits the shifting of the screen to regulate the space between the screen and the background to suit the size of the

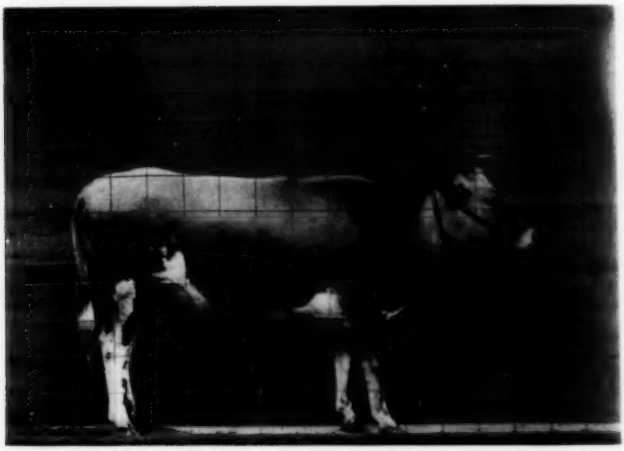


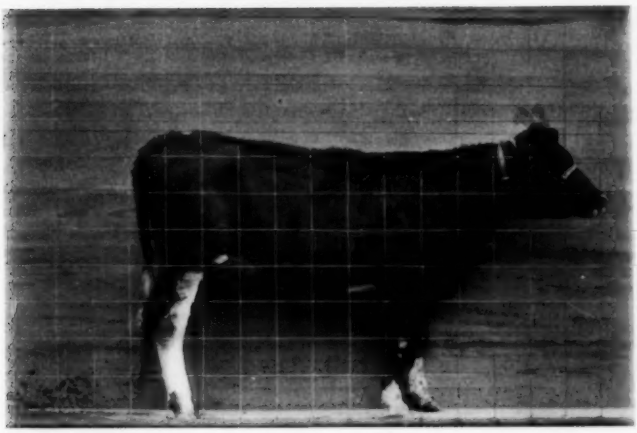
animal. Just enough space should be allowed to permit the animal to stand comfortably. If desired, the background may be made movable and the screen fixed. The apparatus is so arranged that a horse may be hitched to it to move it about.

As stated, the mesh of the screen is 6 inches. It would be better to make the spacing according to the metric system. A mesh of 15 cm. would be about right for cattle. The size of the screen and the mesh should be adapted to the size of the animals to be photographed. The same plan could be used for such small animals as rats and guinea-pigs.

In taking photographs the camera is set a definite distance from the screen. It may be raised and lowered according to

the size of the animal. If the animal does not happen to stand in the center of the screen the camera may be shifted to the right or left.





If desired, the screen may be placed against the background and the animal taken in front of it. If a wider platform is made

and a removable canvas background is used, the front or rear of the animal may be taken.

The writer prefers this method to the one where the lines are painted on the background, for studying comparative size, conformation, location of color markings, extent of color markings, etc. It assists greatly in keeping animals placed while photographs are being taken, resulting in a considerable saving of time and patience. Perhaps, its greatest fault is that it is not well suited to use in direct sunlight on account of the shadows (see figures).

THE PRODUCTION OF VOLATILE FATTY ACIDS AND CARBON DIOXID BY PROPIONIC ACID BACTERIA WITH SPECIAL REFERENCE TO THEIR ACTION IN CHEESE

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INTRODUCTION

Work has been reported elsewhere (4) on the causal factor in the production of eyes and flavor in Emmental or Swiss cheese. The organism used in this work, which has been tentatively designated as Bact. acidi-propionici (d), belongs to the group of propionic-acid-producing bacteria which has been studied by a number of European workers, especially Von Freudenrich and Jensen (2). As has been pointed out, these organisms produce propionic acid, acetic acid, and carbon dioxid from lactose and lactates, the latter supposedly being the source of those compounds in Swiss cheese.

In connection with the cheese-ripening problem it is of interest and importance to know what substances in cheese may serve as sources for carbon dioxid, the production of which is responsible for eye formation, and for volatile acids, especially propionic, which are also probably involved in the development of some of the characteristic properties of cheese of the Emmental type. It is the purpose of the present paper to report some data bearing on this question.

METHODS

In these experiments the media used, with the exception of the tests on pepton alone, consisted of 1 per cent pepton solution with the addition of 2 per cent of the test substance. The organic acids were used in the form of their calcium salts.

The initial reaction of all media was approximately pH 7.0. Incubations were at 30°C.

Volatile fatty acids were determined by the Duclaux method. On the primary steam distillation one liter of distillate was collected from 100 cc. of culture. The neutralized distillate was then evaporated and distilled, according to the original Duclaux method, for the determination of the kinds and proportions of volatile acids present.

In the experiments in which the action of the organism on the volatile acids (formic, acetic, propionic, and butyric) were tested, quantitative and qualitative determinations were made of the volatile acids in the cultures and in sterile media of the same compositions. Any appreciable decomposition of the acid in question should be apparent upon a comparison of the analyses obtained upon the sterile and inoculated media.

Carbon dioxid determinations were made in the special tube designed for this purpose by Eldredge and Rogers (1). Although this method does not give the absolute amount of carbon dioxid produced, since the dissolved gas is not measured, it gives excellent results for comparative purposes. The culture was grown in 30 cc. of the test media and the carbon dioxid produced was absorbed with barium hydroxid. Control tubes containing 1 per cent pepton were also run in each case, and the figures so obtained deducted from the values found with the test substance. Since the organism under consideration produced carbon dioxid quite abundantly from pepton alone, the exact figures obtained from the various test substances are not of great importance. We have reported carbon dioxid production from the test substances, therefore, simply as positive or negative. In the tables in which the amounts of carbon dioxid produced are reported, the results are expressed in terms of the number of cubic centimeter of N/10 $Ba(OH)_2$ neutralized by 30 cc. of culture.

EXPERIMENTAL DATA

The action of the propionic organism, of the type with which we worked, upon the various substances tested is shown in table 1. It should be kept in mind in examining these figures that the

products obtained from the different substances are not quantitatively comparable, due to variable incubation periods and other variable conditions. The results given for lactose and glycerol, which were tested without the presence of a neutralizing agent, are obviously not quantitatively comparable with those obtained in the fermentation of compounds which did not give rise to an increase in hydrogen-ion concentration.

TABLE 1

Action on various compounds

SUBSTANCE	INCUBATION TIME	FERMENTATION	CARBON DIOXID	VOLATILE ACIDS			
				N/20 per 100 cc. of culture			Ratio P:A
				Total	Propionic	Acetic	
	days			*cc.*	*cc.*	*cc.*	
Lactose	30	+	+	99	64	35	1.8
Lactic acid	60	+	+	205	139	66	2.1
Succinic acid	60	+	+	72	42	30	1.4
Formic acid	18	−	−				
Acetic acid	30	−	−				
Propionic acid	60	−	−				
n-Butyric acid	50	−	−				
Iso-butyric acid	50	−	−				
Glycerol	40	+	+	68	46	22	2.1
Butterfat	30	+	+	22	13	9	1.4
Pepton (1 per cent)	30	+	+	10	−	−	−
Pepton (4 per cent)	40	+	+	48	13	35	0.4

From the standpoint of cheese ripening the fermentation of lactose by this organism is probably of little significance, since the sugar in cheese is consumed before the development of eyes and flavor begins. From another point of view we have studied the propionic-acid fermentation of lactose in considerable detail and the material thus collected will be presented elsewhere.

As stated earlier in this paper the fermentation of lactic acid by the propionic organisms is well known and hence needs no especial comment. As may be seen from table 1, however, the lactates of cheese do not constitute the only possible source of carbon dioxid and volatile acids.

The fermentation of succinic acid is of considerable interest since the occurrence of this acid in cheese is well established. If the succinic acid of cheese results mainly from the primary lactose fermentation, as the results of Jensen (3) and of Suzuki, Hastings and Hart (6) would indicate, the presence of succinates at the time the propionic organisms begin their work would seem to be assured. It has been noted elsewhere (4) that this organism differs in some of its characteristics from the published descriptions of the propionic bacteria of Von Freudenrich and Jensen (2). Its action on succinic acid would appear to further justify its designation as a new variety.

The extent to which glycerol may be liberated in ripening cheese is problematical. Although no very extensive decomposition of fat is known to take place in Swiss cheese, it would appear likely that some hydrolysis of fat might result from the complex biological and chemical changes which take place.

Of particular interest is the apparent decomposition of butterfat by the propionic organism. In this connection, however, the possibility of error should be kept in mind. In testing the fat, the volatile fatty acid production was checked by the growth of the organism in the same pepton concentration without the presence of fat. The difference, though small, was constant in the duplicate sample tested. A repetition of the experiment again indicated a decomposition of the fat to about the same extent. While tests of the sterilized fat-pepton medium gave no indication of decomposition upon autoclaving, as revealed by the determination of volatile acids, we must still admit this possibility; and since the organism with which we are dealing ferments glycerol with the formation of the same products, it is possible that the propionic and acetic acids found were the result of a glycerol fermentation of the hydrolyzed portions of the fat.

Should the decomposition of fat by this organism become definitely established, the significance of that fact in the ripening of cheese would be obvious. Even a slight cleavage of fat would probably have a profound influence upon the resulting flavor of the cheese. It is not at all unlikely, moreover, that the characteristic whitish color which develops in Swiss cheese during the ripening process may be due in part to changes in the milk fat.

So far as could be detected by the methods employed, the volatile acids (formic, acetic, propionic, and normal and isobutyric) are not decomposed by this type of propionic organism. In the case of acetic acid the visible growth of the organism appeared to be stimulated somewhat in comparison with its growth in the pepton solution alone; but so far as could be determined analytically there was little if any decomposition of the acetate, nor did the presence of acetate measurably stimulate carbon dioxid production. Determination of the action on acetic acid was complicated by the fact that some acetic acid was

TABLE 2

Carbon dioxid and volatile acids from pepton

CONCENTRATION OF PEPTON	CARBON DIOXID	VOLATILE ACIDS			
		N/20 per 100 cc. of culture			Ratio P:A
		Total	Propionic	Acetic	
per cent		*cc.*	*cc.*	*cc.*	
1	5.1	13.0			
2	10.3	20.2	4.6	15.6	0.3
4	14.9	43.4	13.4	30.0	0.5
8	23.4	82.0	43.6	38.4	1.1

simultaneously produced from the pepton contained in the test medium. But even so, an appreciable destruction of the acetate should have been detected.

From the results obtained on pepton alone it is apparent that some of the nitrogenous constituents of cheese may also serve as sources of carbon dioxid and volatile acids when acted upon by this organism. This is more clearly brought out by the experiment reported in table 2, in which measurements were made of the carbon dioxid and volatile acids produced in pepton solutions of different concentrations.

Since bacteriologic peptones are made partly at least from meat it is obvious that they should contain a little lactic acid. Dr. Rupp of these laboratories has examined a number of samples of commercial peptones for lactic acid and has found this acid,

though constantly present, occurs in amounts too small to account for all of the volatile acids produced by this organism from pepton.

Many possibilities suggest themselves in explanation of the propionic and acetic acid production from nitrogenous compounds. For examples, glutanic and aspartic acids may yield succinic acid, which was shown to be fermented by the propionic organism. A number of amino acids, as for example alanin, may yield lactic acid and hence serve as sources of the volatile acids. We did not have at hand an adequate supply of pure amino acids to undertake a systematic study of this phase of the subject, but we will report here a suggestive result obtained with aspartic acid.

TABLE 3

Influence of aspartic acid on carbon dioxid and volatile acid production

MEDIUM	INCUBATION PERIOD	CARBON DIOXID	VOLATILE ACIDS			
			N/20 per 100 cc. of culture			Ratio P:A
			Total	Propionic	Acetic	
	weeks		cc.	cc.	cc.	
4 per cent pepton	5	24	51	18	33	0.55
4 per cent pepton 0.5 per cent Na. Aspariginate	5	31	60	18	42	0.43
4 per cent pepton	10		61	17	44	0.39
4 per cent pepton, 0.5 per cent Na. Aspariginate	10		83	18	65	0.28

A 4 per cent pepton solution to which was added 0.5 per cent sodium aspariginate was tested, along with a 4 per cent pepton solution as a control, for carbon dioxid and volatile acid production. As indicated by table 3, aspartic acid is probable one of the sources of these products among the nitrogenous constituents of cheese. However, it apparently yields acetic but not propionic acid.

In considering the data presented in this paper on the action of Bact. acidi-propionici (*d*) upon various substances, it is important from the standpoint of cheese ripening to bear in mind the

effect upon this organism of the associated growth of other bacteria. As has been shown elsewhere (5), the propionic fermentation of lactose and lactates may be greatly accelerated by the presence of certain other organisms. If the same phenomenon takes place in the fermentation of other substances, it is not unlikely that the action of the propionic organism is much greater on some of these compounds in cheese than would be expected from the results herein obtained in pure culture studies.

SUMMARY

Observations are recorded concerning the action of Bact. acidipropionici (*d*), the causal factor in the production of eyes and the characteristic sweetish flavor of Swiss cheese, upon various substances which occur in cheese.

Aside from its previously known action upon lactose and lactates, it has been found that this organism can produce carbon dioxid, propionic acid and acetic acid from succinates, glycerol, nitrogenous compounds (pepton), and perhaps to a slight degree, from butterfat.

From pepton the proportion of acetic acid to propionic acid produced was greater than in the cases of the other substances acted upon. Aspartic acid was shown to be able to serve as a source of acetic acid and carbon dioxid.

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III. SODIUM HYPOCHLORITE

THE RATE OF DECOMPOSITION OF SODIUM HYPOCHLORITE IN COW'S MILK

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Hypochlorites are very rapidly decomposed by most organic complexes. Leastwise, raw vegetable and animal extracts absorb the available chlorine spontaneously. Chlorine in the form of its gas, as nitrogen tri-chloride, as chloramines, or as hypochlorites has been considerably exploited as a sterilizing or preserving agent for food products. In view of the severe chlorinating and oxidizing properties of hypochlorites it is very doubtful if they exert any marked selective disinfectant action when conducted into raw mixed food products such as oysters, canned vegetables, meats, milk, etc. In order to exert a preserving power in such substances, the chlorine would necessarily be required to attack the enzymes and microörganisms initially, and only moderately the food products themselves. Practically no work has been published to illustrate any such selective action. It is conceivable that selective might be possible. For instance (*a*) reductases, and (*b*) anaerobic organisms (or their products) might be believed to absorb the chlorine at the greatest rate and hence constitute cases of direct selection. While this is a rather beautiful hypothesis it has not, to my knowledge, been subjected to close scrutiny. It is not the purpose of this paper to specifically attack the problem, but certain results obtained in these studies have shed a few rays of light on instance (*a*) and they will be reported at this time. The second instance (*b*) has been investigated in a manner of attack which is outside the scope of this paper and will be presented at another time.

There is another phase of hypochlorite disinfection more pertinent to the immediate need, and in the data submitted

herewith it will be shown that sodium hypochlorite disappears as such very rapidly in the presence of fresh and pasteurized cow's milk up to the zone of saturation, after which it is absorbed but slowly. The treatment of dairy and other food product utensils with chlorine solutions is a matter of growing interest. End-points in this practice are given scarce concern, so that the operator seldom knows whether enough or too much of the disinfectant is used. There is no chemical or biological data available on what happens to sodium hypochlorite when it comes into contact with milk. Does it exist in milk as such after being added? How much will milk absorb and how fast does milk absorb it at different temperatures? These questions are live biological problems, and it is to help answer them that this and similar work was undertaken

SCOPE AND METHODS OF STUDY

Fresh milk from the dairy was secured which represented a composite from several herds and consisted of both evening's and morning's milking. A portion was kept fresh by packing in ice, a second portion was boiled at 100.2°C. for two minutes, while a third portion was skimmed in the fresh state and then held in ice.

This milk was then subjected to the following study:

1. The Schardinger enzyme test or reductase reaction was applied to each of the three milks to determine the presence of the reductase or reducing bodies in the fresh samples and its absence from the boiled sample.

2. Measured quantities of sodium hypochlorite of standard strength were immediately added to definite quantities of each milk held to constant temperature in a thermostat and the rate of its disappearance determined with sodium iodide solution and starch paste.

3. The rate of absorption of available chlorine from sodium hypochlorite by the fresh skimmed milk was then determined throughout the temperature range of 20° to 70°C.

4. The rate of absorption of available chlorine from sodium hypochlorite by fresh sodium caseinate was then measured at one

temperature (40°C.) in a manner similar to that adopted in "2." The idea was to show that the protein molecule of casein may be the leading agent in milk to decompose the hypochlorites.

5. The hydrogen ion concentration of the sodium hypochlorite treated milk was measured in all cases, to determine the effect of the dilute hypochlorite on the reaction of the milk. This was measured electrometrically with an ionometer cell.

PREPARATION OF THE SODIUM HYPOCHLORITE

In the main the method described in "I. Sodium hypochlorite" (1) was followed, but it will be briefly recounted here. Chlorine from a drum was passed through a flow meter into a solution mixture of 7.5 per cent of NaOH (50 per cent caustic soda) and 2.5 per cent of Na_2CO_3 (anhydrous) until a concentration of 3.25 per cent available chlorine was reached. The chlorination was conducted at room temperature (27°C.) and without any precautions as to the screening from day or sun light. The chlorinated solution was pink to cresol phthalein and blue to thymol phthalein (flash method) but was not pink to powdered phenol phthalein. The hydrogen ion concentration was roughly at pH 10.0. This stock solution of sodium hypochlorite was further diluted to exactly a 1 per cent solution of available chlorine as needed for the above studies.

THE SODIUM IODIDE-STARCH TEST FOR FREE SODIUM HYPOCHLORITE

This test is sensitive to 1 part of sodium hypochlorite in 1,500,000 parts of water when viewed against a white background. Five grams of sodium iodide are added to 100 cc. of a 1 per cent solution of soluble starch. Two-tenths cubic centimeter of this mixture is added to 1 drop of acetic acid held in the depression of a porcelain test-plate. A drop of the milk or other mixture which is to be tested for sodium hypochlorite is placed on the acid-sodium iodide starch mixture and the whole is stirred with a fine platinum wire. A deep blue color denotes much, a purplish considerable, and a faint red-violet a trace of sodium hypochlorite. The color develops immediately.

It should be said here that the test for free hypochlorite needs qualification, because the misapprehension on the part of some as to just what is meant by the test. The starch iodide test has been used extensively to determine the presence of certain oxidizing agents. Starch is used to indicate free iodine. Generally very little thought is given to the reaction of the solution in which the test occurs, except of course to have it sufficiently acid so that the starch-iodine complex will be blue. If the solution is alkaline (above pH 11.0) the blue complex becomes colorless. Now in the test under our consideration we are depending upon the available chlorine in the sodium hypochlorite to set the iodine free and hence form the blue complex. In reality it would not be necessary to add the acetic acid, since the milk itself containing the added hypochlorite is sufficiently on the acid side (pH 6.5 to 7.0) to furnish the correct conditions for the development of the blue color. In fact, a large number of experiments were made without the addition of any acid and substantially the same results were obtained. Under the conditions of the chlorination studied we wish to measure the decomposition of the sodium hypochlorite and not the *iodine-freeing capacity of the chlorinated compounds in the milk*. Whenever any free sodium hypochlorite is present at the reaction of milk it forms a blue compound with starch. A trace of sodium hypochlorite added to milk fails to give a color at all with starch-sodium iodide. A large quantity added to milk gives a blue color. Now, if we add some strong acid (HCl) to the milk containing the trace of sodium hypochlorite we will get a bluish violet coloration with the starch iodide. It is evident that in this latter case we have the product or products of the chlorination furnishing sufficient of some oxidizing substance in the presence of the strong acid to cause the liberation of a trace of iodine. But it would be an error to interpret this as coming directly from sodium hypochlorite. The question can be settled in another manner. If we determine the hydrogen ion concentration of milk to which a trace of sodium hypochlorite has been added we get a very constant potential in a short time at the hydrogen electrode of a calomel halfcell set-up. This is not

true if there is any free sodium hypochlorite present. When hypochlorite is present around the hydrogen electrode (palladiumized platinum) the potential is always very unsteady owing to rapid reduction of the hypochlorite by the nascent hydrogen with the subsequent production of acid products.

The writer holds, therefore, that the work of Rupp (2) recently reported is in error in that Rupp proposed a test to show the presence of hypochlorites and chloramines in milk, whereas these compounds in the concentration added to the milk by Rupp were very likely absorbed in a short time under his working conditions. Any free hypochlorite or *available chlorine* compound present in milk could be determined by merely adding starch-sodium iodide paste, whence a bluish color would result. The substance of Rupp's work is sound, but we believe the statement of the title is misleading, and it is to this that the writer alludes in the preceding argument.

MEASUREMENT OF THE pH OF THE MILK

The electrometric determination of the hydrogen ion concentration of solutions of sodium hypochlorite with a hydrogen electrode is very difficult. It is possible to measure it in very dilute solutions by simply waiting for the catalytic reduction, at the hydrogen electrode, of the contained hypochlorite to equilibriate. This method is not very accurate except in strongly buffered solutions such as milk; even here the small amount of acid reduction products formed from the hypochlorite gives a slightly higher resulting hydrogen ion concentration than actually exists in the presence of the unreduced sodium hypochlorite. Another method of obtaining a fairly steady potential in a dilute hypochlorite solution is to use a flowing hydrogen electrode. This has partially been accomplished by W. A. Noyes (4) in measuring the dissociation of hypochlorous acid with a platinized electrode. It has not been reported before in connection with hydrogen ion measurements in hypochlorite solutions. The principal idea in this method is to provide the platinized or palladiumized electrode with a constantly fresh supply of the *hydrogen-saturated* sodium hypochlorite solution being measured,

during the reading of the potentials, in order to reduce the electrode catalysis to a minimum. Some measurements made in this manner have furnished very good results.

The pH of the *concentrated* hypochlorite solutions were determined colorimetrically, following the suggestions of Cullen (5) but introducing thymolphthalein as a valuable aid in gauging the stable point. The stability of these concentrated solutions of sodium hypochlorite has been mentioned in other connections (1), but it will do no harm to restate that they will remain stable even in the presence of sunlight for several weeks without appreciable loss of available chlorine providing the hydrogen ion concentration is controlled to the proper point during their preparation, viz., pH 10.0 to 10.5.

1. The reductase reaction of the milk samples

Both the Schardinger reaction[1] and the methylene blue reduction test[2] were applied to the three samples of milk.

These tests reacted positively for reducing substances in the raw whole milk and raw skimmed milk. The Schardinger reaction showed complete reduction in the whole milk in thirty minutes, and in the skimmed milk after seventy minutes. The methylene blue reduction test showed complete reduction of methylene blue in the whole milk after two hours, and in the skimmed milk after two and one-half hours.

The boiled milk showed no reduction with either test after a period of ten hours contact.

[1] The Schardinger reaction seems to depend upon the action of some substance (aldehydase) present in milk which is activated by formaldehyde to rapid reduction of methylene blue. It is applied as follows: 5 cc. of a saturated alcoholic solution of methylene blue and 5 cc. of formalin are diluted to 200 cc. with water; 1 cc. of this reagent is added to 20 cc. of milk held at 45°C. in a water bath. Decolorization of the methylene blue shows presence of Schardinger's reductase.

[2] The principle of this reaction is the reduction of methylene blue to methylene white by reducing substances either present in the milk or produced there by microörganisms. It is applied by adding an aqueous solution of medicinal methylene blue to 10 cc. of milk so that the resulting concentration of methylene blue is about 1 to 200,000. The milk is incubated at 37°C.

It was clearly established that there were present in the raw milk reducing substances for the NaOCl to oxidize, while the boiled milk contained a minimum of these.

Precautions were taken to prevent bacterial contamination of the boiled milk previous to making the chlorination tests.

2. Rate of chlorination of raw whole milk, boiled milk and raw skimmed milk

The method of treatment of each type of milk was exactly the same.

One hundred-cubic centimeter portions were placed in Erlenmeyer flasks which in turn were set on the shelf of a circulating water thermostat controlled to a temperature of 30°C. ± 0.2°C.

When they had reached the temperature of the bath the following quantities of sodium hypochlorite (1 per cent available Cl_2) solution were added respectively to each flask of milk. A drop of milk was withdrawn at intervals and tested on the porcelain tile, previously described, for the presence of free sodium hypochlorite. The nearest tenth of one minute when the faint red-violet of the starch-sodium iodide reaction failed to appear was taken as the time required for the respective quantities of available chlorine to become absorbed by the milk in question. Several sets were run to eliminate errors in checking the time factors. When a sample showed complete loss of free sodium hypochlorite it was immediately removed from the bath and set in snow-water to await pH measurement.

The whole milk had a fat content of 3.8 per cent while the skimmed milk contained 0.02 per cent.

In table 1 will be found the average results for the (*a*) raw whole milk, (*b*) heated whole milk, and (*c*) raw skimmed milk.

3. Influence of temperature on the rate of chlorination of milk by NaOCl

Six portions of the raw skimmed milk (*c*) of 100 cc. each were set in their respective water baths heated and controlled to the respective temperatures 20°, 25°, 30°, 40°, 60° and 70°C. Into

each portion was stirred exactly 10 cc. of 0.1 per cent available chlorine solution (0.21 per cent NaOCl solution). At short time intervals a drop of each solution was withdrawn and tested on the porcelain test plate for free NaOCl. The times of first disappearance of free NaOCl from these solutions at the temperatures in question are found in table 2.

TABLE 1

QUANTITY OF MILK	QUANTITY OF NaOCl	Cl_2	RATE OF CHLORINATION			ELECTROMETRIC pH (25°C		
			Raw milk (a)	Heated milk (b)	Skimmed milk (c)	(a)	(b)	(c)
cc	*cc*	*mgms*	*minutes*	*minutes*	*minutes*			
100	None°	None	None	None	None	6.64	6.51	6.62
100	0.5	5	0.15	0.15	0.2			6.65
100	1.0	10	0.85	0.85	0.9			6.69
100	1.5	15	3.75	4.00	4.1			6.72
100	2.0	20	18.5	16.75	17.5			6.85
100	2.5	25	50.0	52.0	55.0			6.91
100	5.0	50	Free NaOCl after four hours					

TABLE 2

MILK	NaOCl	AVAILABLE CHLORINE	TEMPERATURE OF SOLUTION	TIME OF CHLORINATION
cc.	*cc.*	*mgm.*	*°C.*	*minutes*
100	10	10	70	0.8
100	10	10	60	1.5
100	10	10	40	4.5
100	10	10	30	10.5
100	10	10	25	18.5
100	10	10	20	21.5

4. Chlorination of sodium caseinate by NaOCl

A 4.5 per cent solution of sodium caseinate was prepared from pure casein made according to Hammarsten and purified according to Robertson (3). The solution was adjusted to pH 6.5. One hundred-cubic centimeter portions were set in the water bath controlled at 40°C. Sodium hypochlorite of the concentration in "2" was added to the sodium caseinate in the quantities indicated in table 3. The time for disappearance of the free NaOCl was measured.

TABLE 3

Chlorination of sodium caseinate by NaOCl; pH 6.5 (4.5 per cent solution)

SODIUM CASEINATE SOLUTION	NaOCl SOLUTION	AVAILABLE Cl_2	TEMPERATURE OF CHLORINATION	TIME OF CHLORINATION
cc.	*cc.*	*mgm.*	*°C.*	*minutes*
100	1.0	10	40	0.4
100	1.5	15	40	1.2
100	2.0	20	40	2.75
100	2.5	25	40	5.5
100	3.0	30	40	9.0
100	5.0	50	40	20.5

CONCLUSIONS

1. A comparison of the relative time intervals (table 1) for the chlorination of the raw whole, boiled whole and raw skimmed milk, reveals that there is apparently no selective action on sodium hypochlorite by bodies present in the milk which effected the rate of chlorination. Although the boiled milk showed no reduction of methylene blue in either the Schardinger or methylene blue reduction test, it reduced NaOCl with the same speed as the milk which rapidly decolorized methylene blue. If such selective action exists the present test is too clumsy to reveal it.

2. The absorption of chlorine from the hypochlorite is very rapid at first, and as the milk becomes saturated its rate falls off. The presence of 3.8 per cent butter fat does not influence the rate, from which we can assume that the other substances present in the milk are more easily attacked by the NaOCl. The milk seemingly became quite saturated with available chlorine when 100 cc. of milk reacts with 50 mgm. in the form of 55 mgm. of free sodium hypochlorite, or 5 parts in 10,000. This concentration is too small because the 50 mgm. actually show no free NaOCl after five hours at 30°C.

3. Sodium caseinate, freshly prepared from pure NaOH and casein, absorbs available Cl_2 from NaOCl with great rapidity. The protein content of caseinate solution was approximately the same as that in ordinary milk. In preparing the caseinate solution care was taken to avoid alkaline hydrolysis by adding the NaOH to the soaked casein in quantities which held the

hydrogen ion concentration below pH 8.2. The possible influence of the SH groups in the casein molecule is suggested as partially responsible for the rapid absorption of Cl_2. We can believe that much of the chlorine absorbing power of milk is due to the proteins and nitrogenous bodies contained in it.

4. The temperature markedly influences the destruction of NaOCl by milk. This is also true of other types of chlorination reactions. Raising the temperature from 20° to 60°C. decreases the time of chlorination to one-fifteenth of that required at 20°C. This is an important fact to remember in connection with food preserving measures and disinfection of milking machines by sodium hypochlorite.

5. The change in pH of the milk due to the added NaOCl solution did not increase the alkalinity sufficiently to have an appreciable effect upon the speed of chlorination. This point was checked in another manner by rendering the milk slightly alkaline at the start and adding like quantities of NaOCl. Like velocities of chlorination were obtained in each case.

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SOME DETERMINATIONS ON THE SOLUBLE NITROGEN COMPOUNDS OF CREAM AND BUTTER

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In the manufacture of butter, some of the non-fatty constituents of the cream are held in with the fat and become a part of the finished product. The object of this study was to find to what extent certain of these products would be found in butter made from samples of cream varying in age and quality and whether there was a difference in the fresh butter and in their keeping qualities.

Marshal (1) found that the per cent of the total nitrogen in butter not precipitated by phosphotungstic acid, was slightly greater on fresh butter that scored low, than on butter with a higher score, and that the lower scoring butter had the largest increase of soluble nitrogen after being held in storage seven to eight months.

M. E. Pennington (2) states that milk kept in cold storage for two weeks showed pronounced proteolysis, by the single or combined actions of bacteria and enzymes, converting the proteins through caseoses and peptones to amino acids.

Brown (3) reports the per cent of total nitrogen not precipitated by copper sulphate about the same in pasteurized cream butter and in raw cream butter, while the action of typical butter organisms, which were inoculated into milk, was to increase the amount of soluble nitrogen.

[1] The results given in table 1 were obtained by George W. Spitzer and Willis H. Cole, under the general direction of Dr. H. W. Redfield, and acknowledgment is hereby made. Appreciation is also expressed to W. R. North for preparation of the samples made at Grove City; to Mr. L. Jones, Miss D. B. Scott, and Mr. J. I. Palmore, for assistance in making chemical analyses; to the Nitrogen Laboratory for all determinations of total nitrogen, and to Dr. I. K. Phelps, Chemist in Charge of the Food Control Laboratory, for general direction and supervision.

The results reported in this work were on the same samples on which volatile acids and oxidizability value were determined, as shown in the paper entitled "The volatile acids and volatile oxidizable substances of cream and experimental butter" (4). For further information on these samples, reference is also made to the work by North and Reddish (5).

The procedure used in obtaining the results reported in table 1 is as follows:

PROCEDURE FOR CREAM

Two hundred grams of cream were weighed in a 500-cc. wide-mouthed bottle, 4 grams of sodium carbonate, dissolved in a little water, added, and the mixture aerated for six hours into N/10 HCl. The excess acid was titrated and the difference expressed as ammonia. After aeration, the fat was removed from the cream by shaking with gasoline, centrifuging and syphoning off the clear solution. The residue was diluted to 500 cc. and aliquots taken for determination of amino nitrogen and nitrogen not precipitated by phosphotungstic acid as follows: To 25 cc. of the above, representing 10 grams of the original cream, were added 10 cc. of 5 per cent sulphuric acid and 10cc. of a 5 per cent solution of phosphotungstic acid in 5 per cent sulphuric acid and the mixture set aside for fourteen hours. The solution was then filtered and the precipitate washed with 2.5 per cent phosphotungstic acid in 2.5 per cent sulphuric acid until the filtrate and washings measured approximately 100 cc. The nitrogen was determined in this filtrate by the Kjeldahl method. For determination of amino acids, a 50-cc. aliquot of the ammonia free cream was heated to 40° and the casein precipitated by adding a solution of 5 per cent sodium sulphate in 5 per cent acetic acid until slightly acid to methyl red. The mixture was set aside for sixteen hours, filtered, and the precipitate washed with water until the filtrate and washings measured approximately 200 cc. The solution was evaporated on the steam bath to 15 cc., filtered, and the precipitate washed with small amounts of water until the filtrate measured 20 cc. Five-cubic centimeter aliquots of this solution were used for determination of amino acids with Van Slyke's apparatus.

TABLE 1

Showing results on cream and butter made at Denver, 1918

CREAM NUMBER	BUTTER NUMBER	PER CENT OF TOTAL NITROGEN AS								SCORE OF BUTTER		
		Amino nitrogen and Ammonia				Nitrogen not precipitated by phosphotungstic acid						
		Cream	Butter			Cream	Butter					
			Fresh	Cold storage one month	Ice box one month		Fresh	Cold storage one month	Ice box one month	Fresh	Cold storage one month	Ice box one month
15		1.2				7.9						
16		1.6				9.8						
27	B8	2.1	2.5	3.1	3.2	11.2	6.4	9.0	8.3	85	83	82
30		2.3				10.0						
23	B6	2.5	1.1	1.7	2.1	7.7	3.3	3.3	3.0	93	86	86
8		2.7				11.8						
24		2.9				10.5						
14	B1	3.0	1.6	1.8	2.1	8.0	5.3	4.4	6.2	92	90	87
31		3.0				5.3						
4		3.2				6.9						
6		3.2				10.1						
18		3.3				9.5						
20		3.4				9.8						
25	B7	3.4	2.3	2.9	4.3	8.1	3.3	4.9	5.5	90.5	89	85
7		3.5				9.5						
29		3.5				11.3						
5		3.6				7.1						
1		3.7				5.2						
13		3.9				11.6						
17	B3	4.1	2.5	2.8	4.3	9.2	6.5	4.3	6.3	90	89	86
26		4.1				7.9						
28		4.1				10.7						
34		4.2				7.4						
19		4.3				7.9						
10		5.1				8.3						
32		5.1				6.9						
3		5.2				7.6						
21	B4	5.6	1.4	1.4	1.7	4.9	2.3	4.3	3.8	90.5	87	85
33		5.8				8.7						
22	B5	5.9	3.1	3.4	4.0	9.7	5.1	6.7	5.6	87	86	86
12		6.2				9.3						
2		6.8				11.4						
9		8.6				9.8						
11		11.4				16.5						
	B2		2.3	2.5	3.0		5.1	6.5	5.1	91	90	86
	B10		1.7	2.2	2.3		5.2	7.8	6.2	88	86	85
	B9		1.6				2.5			86		

PROCEDURE FOR BUTTER

Six hundred grams of butter were weighed in a quart jar, melted at about 50° and the fat partly syphoned off and the remainder removed with gasoline. The residue was made alkaline with sodium carbonate and aerated, diluted to 300 cc. and aliquots taken for determination of amino nitrogen and nitrogen not precipitated by phosphotungstic acid as in the procedure for cream.

The results on the samples from Grove City, table 2 and following, were obtained by modifying the above procedure as follows: The fat was removed from 100 grams of butter as described in the procedure for detection of neutralizers by Ferris (6). To the fat free residue, 5 cc. of 10 per cent acetic acid and 30 cc. of a saturated solution of picric acid were added, the mixture shaken and filtered. The amino nitrogen and ammonia were determined in 10 cc. of the filtrate by the Van Slyke apparatus and the results calculated to per cent of total nitrogen.

For the determination of the nitrogen not precipitated by phosphotungstic acid, the fat was removed as above and 30 cc. of 3 per cent sulphuric acid and 10 cc. of 5 per cent phosphotungstic acid in 5 per cent sulphuric acid added. The mixture was shaken, allowed to stand a few hours, or over night, filtered, and the nitrogen determined in an aliquot by the Kjeldahl method.

The total nitrogen in butter was determined on the curd which was removed from the fat according to the procedure for fat in butter by Shaw (7).

The results in table 1 show that there is a smaller percentage of the nitrogen present as amino acid and ammonia and as nitrogen not precipitated by phosphotungstic acid in the butter than in the corresponding cream, and, in general, higher results were obtained on cream and butter with the lower score. It is also noticeable that there are higher results for amino nitrogen and ammonia in the butters after being kept in cold storage one month and still higher results on the portions of the samples kept in the ice box at 15° for one month, the increase being correlated in each case with a decrease in score.

For comparison of results on cream and the corresponding buttermilk and butter, a lot of cream was divided into four portions, held under the time and conditions noted in table 2. There is a close agreement of results on the cream and buttermilk, while in two of the cases the per cent of total nitrogen as amino nitrogen is somewhat lower on the butter than on the corresponding cream and buttermilk.

Table 3 shows the amino nitrogen and nitrogen not precipitated by phosphotungstic acid on some high grade sweet cream butters and some low acid cream experimental butters upon which other determinations have been reported elsewhere (8). The results

TABLE 2

Showing amino nitrogen on cream, buttermilk and butter made at Grove City, 1920

SAMPLE NUMBER	CREAM			AMINO NITROGEN AS PER CENT OF TOTAL NITROGEN		
	Inoculated with	Time held days	Temperature	Cream	Buttermilk	Butter
			°C.			
232 C1		3	30–35	4.9	4.4	4.1
232 C2	Bulgaricus	3	30–35	4.3	4.5	4.3
232 C3		4	30–35	5.4	5.3	3.5
232 C4	Peptonizing aerobes	4	30–35	5.9	5.6	3.2

on the experimental butters are slightly higher than on the sweet cream butters, both determinations showing larger amounts of soluble nitrogen after the two periods of storage; five to six months at 22°F and six to seven months at 22°F and then two weeks in the ice box at about 50°F.

The results in table 4 on partially neutralized clean acid cream butter show results similar to those on the experimental butters given in table 3 from cream slightly acid but not neutralized.

Table 5 gives the results on some experimental butters made from cream treated in various ways. Sample 230 B1 was made from pasteurized cream inoculated with pure oidium lactis starter and held two days at room temperature, and 231 B1 from raw cream inoculated with oidium lactis starter and held twenty-four hours. Samples 236 B1, 236 B2, and 236 B3 were made from the same lot of cream held at 20 to 35° for nine days.

TABLE 3

Showing results on regular run sweet cream butter and on butter from cream slightly soured, Grove City, 1920

NUMBER	ACIDITY OF CREAM	SCORE OF BUTTER			PER CENT OF TOTAL NITROGEN AS:					
					Amino nitrogen			Nitrogen soluble in phosphotungstic acid		
		Fresh	Storage	Ice box	Fresh	Storage	Ice box	Fresh	Storage	Ice box
200 B	0.17	93	94	92	1.4	1.9	1.4	3.0	3.4	3.7
201 B	0.16	94	93½	91½	2.3	1.8	2.0	3.7	5.3	4.6
202 B	0.16	94	92	92½	1.8	1.8	2.0	2.4	4.6	3.0
203 B	0.16	94	93	92	1.8	1.6	1.9	3.2	3.9	2.9
204 B	0.17	94	93		1.4	1.3		2.7	3.7	
205 B	0.17	94	93	91	1.5	0.9	1.4	2.6	3.8	3.7
205 B1	0.40	94	91		1.5	1.2		2.1	7.1	
206 B	0.16	94	92	88	1.2	1.8	1.3	2.7	3.9	3.2
207 B	0.16	94	93	88	1.6	1.5	1.5	2.3	4.7	2.4
207 B1	0.24	94	91½		2.1	2.9		3.9	9.5	
208 B	0.16	94	93	89	1.5	1.9	3.0	2.0	3.2	4.1
208 B1	0.25	93	93	86	2.5	2.3	3.3	3.9	5.0	5.2
210 B	0.16	94	93	93	1.1	1.5	1.6	2.9	3.8	2.3
210 B1	0.29	94	93	90	2.6	2.5	3.8	3.9	5.8	6.2
211 B	0.17	94	93		1.3	1.5		3.0	3.2	
211 B1	0.23	93	93		2.1	1.8		3.3	3.5	
213 B	0.15	94	93		0.9	1.4		1.8	3.1	
213 B1	0.31	94	93	88	1.7	2.0	4.1	3.0	3.2	6.6
214 B	0.16	94	93		1.0	1.0		2.6	3.2	
214 B1	0.30	94	93	91	2.0	1.7	2.0	3.4	4.3	4.1
215 B	0.17	94	92½	91	1.1	1.3	1.7	2.4	3.3	2.3
215 B1	0.27	93	92		1.3	1.7		2.7	3.7	
Sweet cream butter "B"										
Maximum					2.3	1.9	3.0	3.7	5.3	4.6
Minimum					0.9	0.9	1.3	1.8	3.1	2.3
Mean					1.4	1.5	1.8	2.7	3.8	3.2
Experimental butters "B1"										
Maximum					2.6	2.9	4.1	3.9	7.1	6.6
Minimum					1.3	1.2	2.0	2.1	3.2	4.1
Mean					2.0	2.0	3.3	3.3	5.3	5.5

Sample 236 B1 was made from raw cream, 236 B2 from pasteurized cream inoculated with pure oidium lactis starter, and 236 B3 from pasteurized cream inoculated with B. lactis acidi starter. This experiment shows that there is greater proteolysis in the butter from raw cream and also greater changes during storage than in pasteurized cream butter.

Samples 232 B1 and 232 B2 were made from raw cream held three days at 30 to 35°, 232 B2 being inoculated with B. bulgaricus starter. Samples 232 B3 and 232 B4 were from raw cream held four days, 232 B4 being inoculated with peptonizing spore-forming aerobes. Since there is no appreciable difference in the determinations on the butters in this experiment between the inoculated cream samples and those not inoculated, it is

TABLE 4

Showing results on experimental butter from neutralized clean acid cream made at Grove City, 1920

NUMBER	ACIDITY OF CREAM	SCORE OF BUTTER			PER CENT OF TOTAL NITROGEN IN BUTTER AS:					
					Amino nitrogen in acetic acid and picric acid filtrate			Nitrogen not precipitated by phosphotungstic acid		
		Fresh	Storage	Ice box	Fresh	Storage	Ice box	Fresh	Storage	Ice box
217 B1	0.35	91	92½	86	1.1	1.9	3.6	2.7	4.3	7.1
218 B1	0.45	91	92½	87	2.8	3.0	5.6	4.6	5.4	9.5
221 B1	0.51	92	92	89	1.9	2.9	3.8	4.2	4.2	6.0
222 B1	0.55	92	93	89	1.5	2.0	2.2	2.9	2.8	4.1
220 B1	0.58	92	93	86	2.6	3.3	3.1	5.2	4.4	4.8
216 B1	0.60	90	93	91	2.7	3.0	2.8	3.8	5.4	4.8
225 B1	0.60	90½	92	89	2.1	3.3	2.9	4.1	4.1	5.8
226 B1	0.62	91	92	89	1.8	2.6	3.0	3.7	3.6	4.3
228 B1	0.63	92	92	89	1.5	2.5	3.0	3.9	3.7	5.3
224 B1	0.65	91	92	88	3.3	3.4	4.9	5.1	5.9	8.2
219 B1	0.67	92	93	91½	1.9	1.9	2.3	3.5	2.9	4.4
227 B1	0.67	91	92	89	2.4	3.7	4.9	4.0	5.3	7.3
Maximum					3.3	3.4	5.6	5.2	5.9	9.5
Minimum					1.1	1.9	2.2	2.7	2.8	4.1
Mean					2.1	2.8	3.5	4.0	4.4	6.0

evident that the cream already contained enzymes or organisms sufficient to produce considerable proteolysis.

Samples 235 B1, 235 B2, and 235 B3, were made from pasteurized cream held at room temperature 3 days, the first being inoculated with B. lactis acidi starter, the second with B. aerogenes, B. coli, and B. lactis acidi, and the third with peptonizing spore-forming aerobes. These three samples showed practi-

TABLE 5

Showing results on experimental butter from treated cream made at Grove City, 1920

SAMPLE NUMBER	CREAM		Held		Acidity	SCORE OF BUTTER			PER CENT OF TOTAL NITROGEN IN BUTTER AS:					
		INOCULATED WITH	Days	Temperature		Fresh	Storage	Ice box	Amino nitrogen in acetic acid and picric acid filtrate			Nitrogen not precipitated by phosphotungstic acid		
									Fresh	Storage	Ice box	Fresh	Storage	Ice box
				°C.										
230 B1	Pasteurized	Oidium lactis	2	Room	0.67	90	93	88	1.9	3.0	2.8	3.4	3.4	5.3
231 B1	Raw	Oidium lactis	1	Room	0.69	89	90	91*	2.9	4.1	4.0*	4.8	5.1	6.6*
236 B1	Raw		9	20–35	0.96	87	89	84	2.8	3.9	4.5	4.9	6.8	7.8
236 B2	Pasteurized	Oidium lactis	9	20–35	0.93	90	89	87	2.1	2.5	2.6	2.9	4.5	4.7
236 B3	Pasteurized	B. lactis acidi	9	20–35	0.97	88	90½	83	1.0	2.2	3.8	3.1	4.2	8.7
232 B1	Raw		3	30–35	0.77	88	92	88	4.1	4.0	3.9	6.0	7.5	5.9
232 B2	Raw	B. bulgaricus	3	30–35	0.87	91	90	90*	3.5	4.6	4.3*	5.9	7.0	7.6*
232 B3	Raw		4	30–35	0.87	88	90	84	3.5	4.3	5.2	5.9	6.3	7.6
232 B4	Raw	Peptonizing spore forming aerobes	4	30–35	0.92	89	90	82	3.2	4.0	6.6	6.2	6.7	7.7
235 B1	Pasteurized	B. lactis acidi	3	Room	0.70	90	90	90½	1.3	1.6	1.7	2.2	2.9	4.3
235 B2	Pasteurized	B. aerogenes, B. coli and B. lactis acidi	3	Room	0.74	91	91	90	1.7	1.7	1.5	2.3	2.7	4.0
235 B3	Pasteurized	Peptonizing spore forming aerobes	3	Room	0.70	90½	91	92	1.5	2.0	1.6	3.1	3.1	5.1
237 B1	Pasteurized	Peptonizing spore forming aerobes	6 3	Room 37-40	1.13	88	83	86	3.0	3.9	3.7	5.1	8.8	9.5
238 B1	Raw	B. aerogenes (developed B. coli bulgaricus)	6 3	Room 37-40	1.76	87	85	83	4.0	5.6	5.6	5.5	7.2	8.2

* These samples were not put in ice box before analyses.

cally the same amount of amino acids and nitrogen not precipitated by phosphotungstic acid as the high grade regular run butters, as shown in table 3.

In order to determine whether more proteolysis would take place if the peptonizers were given a longer time to act, experiment 237 B1 was carried out. Pasteurized cream was inoculated with the peptonizing culture and held at room temperature six days, then at 37 to 40° for three days. The butter from this cream scored only 88 when fresh and fell down greatly in storage; however, the amino nitrogen and nitrogen not precipitated by phosphotungstic acid were only slightly higher than found in neutralized clean acid cream butter, as shown in table 4. Sample 238 Bl was made from raw cream inoculated with B. coli and B. aerogenes and held under the same conditions as 237 B1, when the cream was found to contain bacteria, predominantly B. bulgaricus. The butter from this cream was considerably higher in amino nitrogen and slightly higher in nitrogen not precipitated by phosphotungstic acid than the butters from neutralized clean acid cream.

SUMMARY

Proteolysis of cream, as shown by increase in amino nitrogen and nitrogen not precipitated by phosphotungstic acid in the corresponding butters begins as soon as the cream develops acidity of 0.2 or 0.3 per cent. As these butters were held in storage, there was found to be an increase in the soluble nitrogen compounds, the increase on butters made from sweet cream being slight, while the butters made from neutralized sour cream showed a somewhat greater increase. The greatest per cent of soluble nitrogen, when the butter was fresh, and also the greatest increase during storage, was on butter made from cream which had been allowed to sour before being pasteurized.

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STUDIES IN MILK SECRETION

XI. RELATION BETWEEN THE BUTTERFAT PERCENTAGE OF ONE LACTATION AND THE BUTTERFAT PERCENTAGE OF A SUBSEQUENT LACTATION IN GUERNSEY ADVANCED REGISTRY CATTLE[1]

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In a previous paper it has been shown that a milk record of Guernsey cows making the advanced registry predicts quite exactly what the subsequent record of these same cows will be when put on retest. In other words, physiologically speaking, the control mechanism of the cow when once established regulates quite accurately what the subsequent production of that cow will be. It remains to be shown whether this control mechanism or some similar one will regulate the butterfat percentage of the cow to a similar degree. As important perhaps as a knowledge of whether a butterfat record of a cow is any prediction of her calf's potential possibilities as a milk producer is this knowledge of the worth of one record as an indication of the producing capacity of the cow herself in subsequent lactations. In fact, this knowledge is at the basis of all dairy work, for without it no culling of dairy cattle would be possible, nor would it be profitable to test cattle since the record would be simply an empty number without further significance. It is the purpose of this paper to attempt to solve this relationship and show its true value for the Guernsey breed.

MATERIAL

The data used in this investigation are the same as those of the investigation on milk yield. The American Guernsey Cattle

[1] Paper from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 145. This paper is one of a series of investigations in animal husbandry the continued prosecution of which has been made possible by a grant to the author from The Rockefeller Institute for Medical Research.

Club in its advanced registry tabulates the records of the cows which make the requirements for entry. In volume 31 of this registry there are found to be 738 possible pairs of these test and retest cows under ten years old. From these data the necessary tables were made to determine the degree of relationship which exists between the butterfat percentage of one lactation and that of another lactation. These tables are shown in the appendix to this paper. Because of the slight decrease of the butterfat percentage with advancing age of the cows in the Guernsey breed, it was considered advisable to divide the data into year groups for age of the cows up to the age of six years. The cows whose ages were seven, eight, and nine years were grouped together.

MEAN BUTTERFAT PERCENTAGE OF GUERNSEY TEST AND RETEST COWS

Table 1 gives the average butter fat percentages for the different age groups. The columns represent the mean butterfat percentages of the cows whose ages are indicated above the column. The groups of cows within that age for which the butterfat percentages are subsequently correlated are shown at the left as the age at which the retest was made. Thus, the first mean in the two-year column, 5.15 ± 0.03, shows that these two-year-olds' mean butter fat percentage was 5.15 ± 0.03 per cent and that these same cows were subsequently tested at three years old. Similarly the mean butterfat percentage of the two-year-old cows subsequently retested at four years old was 5.09 ± 0.03 per cent. The mean butterfat percentage of the three-year-old cows tested at two years is given in column headed three years in the two-year row as 5.12 per cent. No striking differences appear in the butterfat percentage of any age group of cows. The butterfat percentage declines with age, it is true, but this is in line with the fact that butterfat percentage does decline slightly in the Jersey, Guernsey, and Ayrshire breeds.

It will be remembered from the previous paper (6) that there was a very distinct increase of the retest cow's milk yield as compared with the milk yield of the cow on first test even within

TABLE 1

Average butter-fat percentage of Guernsey test and retest cows

AGE WITH WHICH CORRELATED	AGE CORRELATED						
	2 years	3 years	4 years	5 years	6 years	7, 8, 9 years	7 years
years							
2		5.12 ± 0.03	5.02 ± 0.03	5.02 ± 0.05	4.83 ± 0.04	4.80 ± 0.04	
3	5.15 ± 0.03		5.19 ± 0.04	4.90 ± 0.05	5.08 ± 0.05	4.92 ± 0.05	
4	5.09 ± 0.03	5.22 ± 0.04		5.09 ± 0.05	4.98 ± 0.05	4.80 ± 0.06	
5	5.07 ± 0.04	4.90 ± 0.04	5.11 ± 0.05		5.02 ± 0.07	4.89 ± 0.06	
6	4.94 ± 0.04	5.19 ± 0.05	5.05 ± 0.04	5.04 ± 0.06		4.95 ± 0.05	
7, 8, 9	5.05 ± 0.04	5.21 ± 0.05	4.97 ± 0.06	4.95 ± 0.06	4.99 ± 0.05		5.01 ± 0.07
8 and 9							4.95 ± 0.06

the same age groups. This increase in milk yield appears to be due to the development of the cow, to special treatment accorded the cow in retest, or to the education of her owner in the proper handling of cattle for advanced registry testing. In either case the result is brought about largely as an environmental effect, the consequences of the effect being sufficiently large to justify careful attention to this phase of the training of cattle and men for advanced registry testing.

The effect of this training is all on the milk yield, for if an examination is made of table 1 to compare the records of test and retest cows, it is seen that they do not differ appreciably in their mean butterfat percentage within the same age groups. The possibilities of using this developmental effect in increasing milk seem to be limited to the increasing of the milk yield and not to increasing the butterfat percentage. The butterfat percentage appears quite stable and resistant to such an influence.

VARIATION OF THE BUTTERFAT PERCENTAGE OF GUERNSEY TEST AND RETEST COWS

Table 2 gives the variation in butterfat percentage which these Guernsey cows showed in their first and second tests. This variation is recorded as the standard deviation. Within limits of three times the standard deviation on either side of the mean butterfat percentage of table 1 are included practically all the observed butterfat percentages of this group of cows. The arrangement of table 2 is the same as that of table 1.

The variability with the different age groups appears to be at random. Of the standard deviation for the individual ages that for the two-year-olds subsequently tested at six years old is probably too low. The variability of the seven-year group tested again at eight or nine years is high. These differences are probably due to random sampling and not to any real differences. The other standard deviations vary within rather narrow limits. The variability expressed in terms of the mean ranges from 7.3 to 10.1 per cent. This variation is closely similar to like data on the butterfat percentage of purebred Jersey cows (5), Ayrshire cows (8), and Holstein-Friesian cows (2).

TABLE 2

Differences between butterfat percentage for Guernsey retest cows in first and second tests

AGE WITH WHICH CORRELATED	AGE CORRELATED						
	2 years	3 years	4 years	5 years	6 years	7, 8, 9 years	7 years
years							
2		0.456 ± 0.021	0.447 ± 0.020	0.444 ± 0.031	0.413 ± 0.030	0.440 ± 0.032	
3	0.440 ± 0.020		0.433 ± 0.028	0.496 ± 0.036	0.404 ± 0.033	0.466 ± 0.036	
4	0.429 ± 0.019	0.491 ± 0.032		0.458 ± 0.038	0.458 ± 0.034	0.449 ± 0.043	
5	0.449 ± 0.029	0.423 ± 0.031	0.454 ± 0.037		0.438 ± 0.049	0.486 ± 0.041	
6	0.362 ± 0.026	0.401 ± 0.033	0.452 ± 0.033	0.388 ± 0.044		0.497 ± 0.038	
7, 8, 9	0.427 ± 0.030	0.461 ± 0.038	0.419 ± 0.040	0.487 ± 0.041	0.449 ± 0.035		0.507 ± 0.052
8 and 9							0.444 ± 0.045

TABLE 3

Correlation coefficients between the butterfat percentages of one lactation and those of another lactation

AGE WITH WHICH CORRELATED	AGE CORRELATED						
	2 years	3 years	4 years	5 years	6 years	7, 8, 9 years	7 years
years							
2		0.822 ± 0.021	0.780 ± 0.025	0.780 ± 0.036	0.684 ± 0.054	0.637 ± 0.060	
3	0.822 ± 0.021		0.829 ± 0.028	0.802 ± 0.037	0.737 ± 0.053	0.764 ± 0.048	
4	0.780 ± 0.025	0.829 ± 0.028		0.800 ± 0.046	0.868 ± 0.026	0.736 ± 0.062	
5	0.780 ± 0.036	0.802 ± 0.037	0.800 ± 0.046		0.812 ± 0.038	0.893 ± 0.024	
6	0.684 ± 0.054	0.737 ± 0.053	0.868 ± 0.026	0.812 ± 0.038		0.882 ± 0.024	
7, 8, 9	0.637 ± 0.060	0.764 ± 0.048	0.736 ± 0.062	0.893 ± 0.024	0.882 ± 0.024		
8 and 9							0.838 ± 0.043
Average.....	0.741	0.791	0.803	0.817	0.797	0.782	0.838

RELATION BETWEEN THE BUTTERFAT PERCENTAGE OF THE FIRST TEST AND OF THE RETEST

With these data at hand it is now possible to measure the degree of reliance which may be placed in one advanced registry record for butterfat percentage as an indication of what that cow may do on another advanced registry test. It is the answer to this problem which makes the advanced registries worthy or unworthy. Table 3 gives the correlation coefficients for one lactation's butterfat percentage record with that of another.

Study of table 3 shows that the correlation coefficients for the butterfat percentage of one lactation correlated with that of another lactation are high for that kind of data. The average weighted correlation coefficient for all tests is 0.792 when each observation is equally weighted. The differences in the individual correlation coefficients appear to be due to chance. Such being the case, the results lead to the important practical conclusion that a cow beginning her lactating career as a two-year-old with a high butterfat percentage may be expected to duplicate this relatively high performance. The first lactation records as to the butterfat percentage which a given cow will produce are, then, good indices of what may be expected in future years. Selection of cows on the basis of such records is profitable to the dairyman.

Some comparative records along these lines are of interest. The data given in table 4 furnish this information.

Table 4 (3, 4, 5, 6, 7) shows that a butterfat percentage record of advanced registry Guernsey cows predicts more accurately the butterfat percentage of a subsequent lactation than an advanced registry milk record predicts the milk yield of a subsequent lactation. Thus, the average correlation coefficient between the various butterfat percentages of different lactations is 0.792, while the average correlation coefficient of the various milk yields of different lactations is 0.696, or the butterfat record is approximately 1.1 times as good an index of the subsequent lactation records as is a milk production record an index of the subsequent lactations' milk yields.

TABLE 4

Correlation coefficients between characters of economic importance

CHARACTER	BREED	CORRELATION	AUTHORITY
Butterfat percentage and butterfat percentage	Guernsey advanced registry	0.637 to 0.893	This paper
Milk yield and milk yield	Guernsey advanced registry	0.462 to 0.811	Gowen (6)
Butterfat percentage and butterfat percentage	Jersey pure-bred herd	0.247 to 0.678	Gowen (5)
Milk yield and milk yield	Jersey pure-bred herd	0.214 to 0.731	Gowen (4)
Monthly egg yield and other 11-months' production	White Leghorn	0.240 to 0.573	Harris and Blakeslee (7)
Milk yield and score (conformation)	Jersey registry of merit	−0.070 to +0.194	Gowen (3)

It will be noted that an advanced registry record of Guernsey cows, whether for milk yield or butterfat percentage, is a more reliable guide to what those cows will do in a subsequent advanced registry test than are the records of a pure-bred herd of Jersey cattle. Advanced registry cattle are a selected group of cattle. The comparison of these selected Guernsey cows with those of a pure-bred herd of Jerseys where no selection has been practiced indicates that the reliance which may be placed in the butterfat percentage and milk records of an unselected group of cattle is slightly less than can be placed in the records of the selected group. This does not mean that the records of the unselected group may not be as accurately taken as the records of the advanced registry group. The correlations in all cases are high for butterfat percentage or for milk yield. Such high correlation coefficients indicate that the individual cows are innately differentiated in their capacity for producing a high or low butterfat percentage or a high or low milk yield.

The correlation coefficients between the monthly egg production and the other-eleven-months' production of the White Leghorn hens show a similar range to those of the various butterfat percentages except that they are considerably lower in value. Such being the case, a greater reliance may be placed in a milk or butterfat percentage record than may be placed in an egg record.

Conformation has played and is playing a large part in the selection of cows for milk production. It does not occupy so wide a place in the selection of cows for butterfat percentage, in fact has little relation to it. The selection of cows is based on the hope of future returns from these cows as milk and butterfat producers. Table 4 brings out in striking comparison the relative values of a milk record and a judgment on conformation as an indicator of the cow's future production. Thus if the character having the highest relation to milk production total score, is compared with a record for milk yield, it is seen that a milk record of Guernsey advanced registry cows is $3\frac{1}{2}$ times as good an indicator of what the cow will do in a subsequent lactation as is any point of conformation. Not only that but con-

formation throws little or no light on a cow's butterfat percentage, whereas the Babcock test applied to a cow's milk indicates quite clearly what that cow's milk will test for butterfat in a subsequent lactation. It seems doubtful if greater proof is needed of the desirability of testing cattle.

One other thing is needed to make any record of value in predicting another, the factor necessary to convert one record into another must be known.

TABLE 5

Equations to predict the probable butter-fat percentage of Guernsey advanced registry cows on second test

BF $\%_2 = 1.088 + 0.793$ bf $\%_3$	BF $\%_3 = 0.735 + 0.852$ bf $\%_2$
BF $\%_2 = 1.318 + 0.750$ bf $\%_4$	BF $\%_4 = 0.893 + 0.812$ bf $\%_2$
BF $\%_2 = 1.105 + 0.790$ bf $\%_5$	BF $\%_5 = 1.109 + 0.771$ bf $\%_2$
BF $\%_2 = 2.037 + 0.600$ bf $\%_6$	BF $\%_6 = 0.982 + 0.780$ bf $\%_2$
BF $\%_2 = 2.087 + 0.617$ bf $\%_{7-8+9}$	BF $\%_{7,8,9} = 1.484 + 0.657$ bf $\%_2$
BF $\%_3 = 0.341 + 0.940$ bf $\%_4$	BF $\%_4 = 1.377 + 0.730$ bf $\%_3$
BF $\%_3 = 1.556 + 0.683$ bf $\%_5$	BF $\%_5 = 0.276 + 0.943$ bf $\%_3$
BF $\%_3 = 1.479 + 0.731$ bf $\%_6$	BF $\%_6 = 1.223 + 0.743$ bf $\%_3$
BF $\%_3 = 1.326 + 0.790$ bf $\%_{7-8+9}$	BF $\%_{7,8,9} = 1.066 + 0.739$ bf $\%_3$
BF $\%_4 = 1.076 + 0.792$ bf $\%_5$	BF $\%_5 = 0.969 + 0.807$ bf $\%_4$
BF $\%_4 = 0.783 + 0.856$ bf $\%_6$	BF $\%_6 = 0.539 + 0.880$ bf $\%_4$
BF $\%_4 = 1.679 + 0.687$ bf $\%_{7-8+9}$	BF $\%_{7,8,9} = 0.870 + 0.790$ bf $\%_4$
BF $\%_5 = 1.432 + 0.719$ bf $\%_6$	BF $\%_6 = 0.392 + 0.918$ bf $\%_5$
BF $\%_5 = 0.567 + 0.896$ bf $\%_{7-8+9}$	BF $\%_{7,8,9} = 0.484 + 0.891$ bf $\%_5$
BF $\%_6 = 1.051 + 0.796$ bf $\%_{7-8+9}$	BF $\%_{7,8,9} = 0.073 + 0.977$ bf $\%_6$
BF $\%_7 = 0.267 + 0.957$ bf $\%_{8+9}$	BF $\%_{8,9} = 1.281 + 0.733$ bf $\%_7$

PREDICTION OF RETEST BUTTERFAT PERCENTAGE FROM THE FIRST TEST BUTTERFAT PERCENTAGE

These conversion factors may be put in the form of equations to predict one of the variables from another. These equations to predict the probable butterfat percentage of one lactation from that of another have been calculated for these advanced registry Guernsey cows. They are given in table 5.

In the equations of table 5, BF percentage represents the desired predicted butterfat percentage at the subscript age, and bf percentage indicates the butterfat percentage at the age given as the subscript to the bf percentage. Thus a cow at two years

old gives a milk whose butterfat percentage is 6.0 per cent, which would be the expected advanced registry butterfat percentage at six years of age. We find the BF percentage of six years and the bf percentage of two years in the fourth equation of column 2. This equation is

$$\text{BF percentage}_6 = 0.982 + 0.780 \text{ bf percentage}_2$$

substituting, we have BF percentage$_6$ = 0.982 + 0.780 × 6.0, or the expected butterfat percentage at six years is 5.662 per cent. By the same process the required probable butterfat percentage of any age may be found.

SUMMARY

This paper presents data to show the reliability of an advanced registry record of Guernsey cattle in predicting what the cow's butterfat percentage will be in a subsequent advanced registry retest for other lactations. The principle facts resulting from this study may be briefly stated as follows.

Unlike milk yield, the butterfat percentage of these Guernsey advanced registry cows shows no increase on retest. It remains approximately the same in the retest as in the first test.

The variation of the butterfat percentage is closely similar to that of other breeds of cattle.

The relation of the butterfat percentage of one lactation to that of another is high, ranging from 0.637 to 0.893 in terms of the correlation scale. The average correlation coefficient is 0.792. This average is $1\frac{1}{10}$ times as high as that for milk yield of these same cows, or a butterfat percentage record may be more accurately predicted from a previous test than can a record for milk yield be predicted from a previous test. Comparison of these results with records of a pure-bred Jersey herd for the relation of one lactation to another indicates that the advanced registry records predict a subsequent advanced registry performance more accurately than would be expected to be the case for all Guernsey cows.

A comparison of the value of a month's egg record in predicting the other eleven months' record with Guernsey butterfat

percentage records shows that a Guernsey butterfat percentage record predicts more accurately the subsequent butterfat percentage record than does an egg record predict the subsequent performance of the hen.

Comparison of scoring as a method of selecting cattle for milk yield or butterfat percentage with an advanced registry record for selecting milch cows shows the advanced registry record to be several times more valuable than the score card.

Equations are presented to determine from one lactation's advanced registry butterfat percentage record what the probable butterfat percentage record at a subsequent lactation will be.

APPENDIX

TABLES SHOWING THE CORRELATION SURFACE FOR THE VARIABLE BUTTER-FAT PERCENTAGE OF ONE LACTATION WITH THE BUTTER-FAT PERCENTAGE OF ANOTHER LACTATION. EACH LACTATION IS AT A KNOWN AGE

3-YEAR-OLDS' BUTTER-FAT PERCENTAGE	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE												
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2 to 6.4	
3.8 to 4.0	1												1
4.0		1	1										2
4.2	1			2									3
4.4		2	2	3									7
4.6	1		2	2	5	4							14
4.8				3	3	2	1	1					10
5.0				2	6	9	6	2	1				26
5.2						1	9	5	1	1			17
5.4						1	1	6				1	9
5.6						1	2	2	4				9
5.8						1		2	1	1			5
6.0 to 6.2										1	2		3
	3	3	5	12	14	19	19	18	7	3	2	1	106

4-YEAR-OLDS' MILK YIELD (POUNDS)	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE												
	3.8 to 4.0	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
3.8 to 4.0	1		1										2
4.0			1	1									2
4.2		1	3	2	1								7
4.4			1	1	2	3	2						9
4.6				2	3	3	2		1				11
4.8		1		1	7	5	7	1	5				27
5.0							8	1	3				12
5.2						2	3	10	6	1	1		23
5.4							3	4	3	2	1		13
5.6								1	3	1	1		6
5.8													
6.0 to 6.2								1		1		1	3
	1	2	6	7	13	13	25	18	21	5	3	1	115

5-YEAR-OLDS' BUTTER-FAT PERCENTAGE	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE											
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
4.0 to 4.2		1										1
4.2	1		1									2
4.4			3	5								8
4.6		1	1	1	1	2	1	1				8
4.8				1	1	2						4
5.0			2		1	4	3	1	1			12
5.2					1	3	2	2	1			9
5.4							1	3				4
5.6									2		1	3
5.8										1		1
6.0												
6.2 to 6.4								1				1
	1	2	7	7	4	11	7	8	4	1	1	53

6-YEAR-OLDS' BUTTER-FAT PERCENTAGE	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE									
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6 to 5.8	
3.8 to 4.0		1								1
4.0				1						1
4.2	1			2	1					4
4.4		1	4	2	1					8
4.6				1	4	1		1		7
4.8		1		1	1	4		2		9
5.0					1	3	2			6
5.2					1		1		1	3
5.4						1	2			3
5.6 to 5.8							2			2
	1	3	4	7	9	9	7	3	1	44

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE								
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6 to 5.8	
4.0 to 4.2	1	3							4
4.2	1	1	2	1					5
4.4	1			2	1	1			5
4.6	1		1			2	4	1	9
4.8			2	1	4	1			8
5.0			1	1	2		2		6
5.2						1	1	1	3
5.4								2	2
5.6									
5.8 to 6.0						1	1		2
	4	4	6	5	7	6	8	4	44

4-YEAR-OLDS' BUTTER-FAT PERCENTAGE	3-YEAR-OLDS' BUTTER-FAT PERCENTAGE										
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
4.0 to 4.2	1										1
4.2		1									1
4.4		3									3
4.6		3	2	2							7
4.8			1	2	3						6
5.0				1	4	1	1				7
5.2			1	1	2		3	2	1	1	11
5.4					2	3	3	2	1		11
5.6					1	1			2	1	5
5.8										1	1
6.0 to 6.2									1	1	2
	1	7	4	6	12	5	7	4	5	4	55

5-YEAR-OLDS' BUTTER-FAT PERCENTAGE	3-YEAR-OLDS' BUTTER-FAT PERCENTAGE									
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6 to 5.8	
4.0 to 4.2	2	1	1							4
4.2		2	2							4
4.4		1		2	1					4
4.6			1	3	2			1		7
4.8				4	2		1			7
5.0					1	2	2			5
5.2					1	1	2		1	5
5.4							2	3		5
5.6										
5.8										
6.0 to 6.2					1				1	2
	2	4	4	9	8	3	7	4	2	43

6-YEAR-OLDS' BUTTER-FAT PERCENTAGE	3-YEAR-OLDS' BUTTER-FAT PERCENTAGE								
	4.4 to 4.6	4.6	4.8	5.0	5.2	5.4	5.6	5.8 to 6.0	
4.2 to 4.4	1	1							2
4.4	1								1
4.6		4	2		1				7
4.8			1	2		1	1		5
5.0			1	1	1	3			6
5.2			1	2		1			4
5.4					1	1	1	1	4
5.6 to 5.8				1		2		2	5
	2	5	5	6	3	8	2	3	34

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	3-YEAR-OLDS' BUTTER-FAT PERCENTAGE										
	4.4 to 4.6	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2 to 6.4	
4.2 to 4.4	1		1								2
4.4	2	2	2				1				7
4.6	1		3		2	2					8
4.8			3	1							4
5.0					1		3				4
5.2				1		2	2				5
5.4						1	1	1			3
5.6											
5.8											
6.0											
6.2											
6.4 to 6.6										1	1
	4	2	9	2	3	5	7	1		1	34

5-YEAR-OLDS' BUTTER-FAT PERCENTAGE	4-YEAR-OLDS' BUTTER-FAT PERCENTAGE									
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8 to 6.0	
4.2 to 4.4	1	1								2
4.4	1		1							2
4.6		1	2	3	2					8
4.8		1								1
5.0			2		2		1			5
5.2				1		3	2	2		8
5.4							3		1	4
5.6										
5.8									1	1
6.0 to 6.2						1		1		2
	2	3	5	4	4	4	6	3	2	33

6-YEAR-OLDS' BUTTER-FAT PERCENTAGE	4-YEAR-OLDS' BUTTER-FAT PERCENTAGE										
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
4.0 to 4.2	2										2
4.2		1		1							2
4.4	1	3	1	1							6
4.6	1		3	1							5
4.8				4	2		1				7
5.0				1	1	2	2				6
5.2				1		2	2				5
5.4				1		1	4				6
5.6									1	1	2
5.8											
6.0										1	1
6.2 to 6.4											
	4	4	4	10	3	5	9	1	1	1	42

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	4-YEAR-OLDS' BUTTER-FAT PERCENTAGE								
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6 to 5.8	
4.0 to 4.2		1	2						3
4.2	1	1	1	1					4
4.4			1	1					2
4.6	1					1			2
4.8	1			1	3				5
5.0				1	1	1	1		4
5.2						1		1	2
5.4 to 5.6					1			2	3
	3	2	4	4	5	3	1	3	25

6-YEAR-OLDS' BUTTER-FAT PERCENTAGE	5-YEAR-OLDS' BUTTER-FAT PERCENTAGE								
	4.4 to 4.6	4.6	4.8	5.0	5.2	5.4	5.6	5.8 to 6.0	
4.0 to 4.2	1								1
4.2	1								1
4.4									
4.6	1	1	1						3
4.8		1	3						4
5.0				2	1				3
5.2					2		1		3
5.4								1	1
5.6					1				1
5.8 to 6.0					1				1
	3	2	4	2	5		1	1	18

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	5-YEAR-OLDS' BUTTER-FAT PERCENTAGE													
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4 to 6.6	
4.0 to 4.2		1	2											3
4.2	1	1		1										3
4.4		1												1
4.6			2	2	1	1								6
4.8			1	1	1	1	2							6
5.0					1	3	2							6
5.2						2	1	1						4
5.4								1	1					2
5.6														
5.8														
6.0														
6.2														
6.4 to 6.6													1	1
	1	3	5	4	3	7	5	2	1				1	32

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	6-YEAR-OLDS' BUTTER-FAT PERCENTAGE										
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
4.0 to 4.2		1									1
4.2	1		2								3
4.4	3		3		1						7
4.6		2		2	1						5
4.8			1	3	1						5
5.0				1	4	2					7
5.2					3	1	1				5
5.4					1			1			2
5.6									1		1
5.8											
6.0										1	1
6.2											
6.4 to 6.6										1	1
	4	3	6	6	11	3	1	1	1	2	38

8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	7-YEAR-OLDS' BUTTER-FAT PERCENTAGE												
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4 to 6.6	
3.8 to 4.0	1													1
4.0														
4.2			1											1
4.4		1		1	1	1								3
4.6				2										2
4.8				4	1	1								6
5.0						1								1
5.2					1		2	2						5
5.4							1							1
5.6 to 5.8									1				1	2
	1	1	1	6	3	3	3	2	1				1	22

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STUDIES IN THE GROWTH AND NUTRITION OF DAIRY CALVES

VI. THE ADDITION OF HAY AND GRAIN TO A MILK RATION FOR CALVES

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The necessity of investigating the effects of rations selected from limited sources is now recognized as of vital importance in arriving at a true idea of certain nutritional processes. In order to determine the true or relative value of any feed for a given class of animals, it is necessary that it be fed with a wide variety of other feeds and also as the sole constituent of the ration, if it is of such a nature as to render this possible. A thorough understanding of the physiological value of any feed can only be arrived at after a series of correlated investigations, the results of which can be studied as a group.

The work outlined here was undertaken to expand results reported in paper V of this series and to determine the relative values of rations consisting of milk, milk and mixed grains, and milk and alfalfa hay for young calves.

RÉSUMÉ OF PREVIOUS WORK

Investigations bearing directly on the problem under consideration are limited in number as little work of this character has been undertaken with farm live stock. There are, however, reports of investigations with laboratory animals which aid to some extent in the explanation of the results obtained.

The results available on the use of limited rations for ruminants are meager. Plumb (51) fed one pen of calves on whole milk and two pens on skim milk, for a period of two to three months without observing any bad effects from the limited ration. Sanborn (52) placed a calf weighing 180 pounds on a ration of milk and grain, and the animal is reported to have eaten the sawdust used as bedding and died of indigestion.

In an attempt to grow cattle without the use of roughages, Davenport (39) found that grain fed in amounts up to half a bushel daily to a five-month old calf did not satisfy the craving for feed. Disturbances of the nerve centers and swelling of the joints were noticed. A second calf, fed exclusively on skim milk until seven months of age, when it was in quite poor condition, was then placed on coarse feed and recovered rapidly. A third individual, fed milk and grain, was extremely reduced in condition at five months of age, but recovered when allowed hay. A fourth calf, which received no roughage, died at three months of age. A post-mortem examination showed that the muscles were hard and firm and no internal fat was present.

That growth and reproduction were seriously affected by limiting the ration of dairy heifers to the products of a single cereal plant was found by Hart, McCollum, Humphrey and Steenbock (45, 46). It was also reported in paper V of this series that calves could not exist for extended periods on a ration of whole milk alone.

In an investigation with hogs, Burnett (35, 36) found that limiting the ration to corn markedly affected bone growth and development and the breaking strength of the bones of the legs. In the case of work done by McCollum and reported by Henry (47) it was found that a sow could be raised to maturity and reproduce normally with milk as the sole feed, though Evvard and Glatfelter (42) report that better success was obtained in the raising of orphan pigs where eggs, tomato juice or orange juice were added to the ration than where milk alone was fed.

It has been stated by Forbes (43) that the specific effects of feeds on growing animals are due largely to the mineral elements in the feed and especially to the relation between the calcium and magnesium, while the importance of the vitamines has been emphasized by many and the work of this character, though little of it with ruminants, has been summarized quite completely by Blunt and Wang (32, 33). However, Dutcher, Kennedy and Eckles (41) report that the milk of cows on pasture is richer in water soluble C than is that of cows on winter feed.

EXPERIMENTAL WORK

In this work six calves were used, of which five were bulls and the other was presumed to be a freemartin as it was twinned with a bull. All but the freemartin were grades. The calves were allowed to suck their dams for a few days after birth and were then put on the experimental rations. They were divided into three lots and information concerning the individuals is given in table 38.

After the calves were taken from their dams, milk was fed to them three times daily in amounts indicated by their ability to handle it. Salt was accessible at all times and they had access to water for several hours daily though they were confined in pens. In addition, lot II was allowed to consume at free will a grain mixture consisting of 5 parts cracked corn, 2 parts ground

TABLE 38

Animals used

	LOT I—MILK		LOT II—MILK AND MIXED GRAIN		LOT III—MILK AND ALFALFA HAY	
	Calf 479 (grade Guernsey)	Calf 489 (grade Holstein)	Calf 498 (grade Jersey)	Calf 502 (grade Guernsey)	Calf 488 (grade Holstein)	Calf 495 (Holstein)
Birth weight, pounds	76	85	51	68	66	65
Sucking days	4	3	5	6	2	5

oats, 2 parts wheat bran and 2 parts old-process linseed oil meal by weight, while lot III always had access to alfalfa hay.

Complete records of feed consumption were kept and these have been combined by thirty-day periods throughout the various experiments. The weights of the animals were determined on three successive days in the middle of each period and from these the live weights at the end of each experimental period were determined. Body measurements were obtained in a similar manner though only taken on one day. In the final computations it was assumed that the milk consumed during the few days that the animals sucked their dams was the same in amount as that consumed in a like period after hand feeding was started.

The calves did not all start on experiment at the same time, due to differences in date of birth, but in the tabulations they are kept together on the age basis. The inequalities near the finish are due to the fact that the experiments were all closed about the same time irrespective of the ages of the calves. However, to avoid complications, the records for the animals which lived throughout the work are given to the end of the last thirty-day period that was completed.

Rations

Lot I—milk. The calves in this group were fed a ration of whole milk throughout the trial. When they became weak and low in condition, alfalfa hay was introduced into the ration. This introduction took place at the beginning of period VIII for calf 479 and on the nineteenth day of period VI in the case of calf 489. For a few days the allowance of hay was limited and then it was given at free will.

Lot II—milk and grain. This group received milk throughout the experiment and in the latter part of period II the grain mixture was introduced and kept before the animals at all times. Calf 502 died on the sixteenth day of period V after consuming little feed during the last two weeks of its life. At the beginning of the sixth period, alfalfa hay was given to calf 498, at first in limited amounts, and later at free will.

Lot III—milk and alfalfa. These calves had milk throughout the experiment, and alfalfa hay was introduced in the latter part of the first period for calf 495 and in the early part of the second period for calf 498 and from then on was allowed at free will.

Growth of calves

The records of the increase in live weight and body measurements of the calves are indications of the suitability of the rations for the calves. For this reason the birth weights of the calves and their weights at the end of each completed thirty-day period are given, as are the body measurements taken, height at withers, depth of chest and width at hooks.

TABLE 39

Feed records

PERIOD	FEED							
	Whole milk		Alfalfa hay		Mixed grain		Salt	
Lot I—milk ration								
	Calf 479	Calf 489	Calf 479	Calf 489	Calf 479	Calf 489	Calf 479	Calf 489
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
I	351	333					0.01	0.21
II	450	489					0.39	0.09
III	482	599					0.10	0.18
IV	540	630					0.10	0.33
V	630	630					0.29	0.27
VI	630	630		45*			0.26	0.18
VII	630	630		149			0.17	0.10
VIII	630	630	86	204			0.10	0.04
IX	630		121				0.15	
Lot II—milk and mixed grain ration								
	Calf 498	Calf 502	Calf 498	Calf 502	Calf 498	Calf 502	Calf 498	Calf 502
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
I	218	216					0.04	0.06
II	246	267			2	10	0.09	0.08
III	270	270			26	32	0.12	0.06
IV	270	270			60	50	0.04	0.02
V	270	30†			82	x2	0.02	0.01†
VI	270		59		57		0.08	
VII	270		108		30		0.10	
Lot III—milk and alfalfa ration								
	Calf 488	Calf 495	Calf 488	Calf 495	Calf 488	Calf 495	Calf 488	Calf 495
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
I	298	307		9			0.02	0.04
II	462	450	27	36			0.02	0.05
III	450	450	73	96			0.11	0.08
IV	450	450	184	168			0.11	0.11
V	450	450	264	220			0.19	0.26
VI	450		313				0.45	

* Last twelve days of period VI for calf 489.

† Calf 502 died on the sixteenth day of period V and for two weeks prior to this consumed little feed.

TABLE 40

Live weights and body measurements of calves

PERIOD	GROUP						
	Normal	Lot I		Lot II		Lot III	
		Calf 479	Calf 489	Calf 498	Calf 502	Calf 488	Calf 495
Live weight							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Birth	67	76	85	51	68	66	65
I	90	94	123	69	71	133	95
II	120	124	162	92	83	166	143
III	163	161	217	128	112	241	210
IV	211	177	271	165	113	322	266
V	262	212	315	187		399	339
VI	314	252	382	220		469	
VII	366	265	462	253			
VIII	413	289	530				
IX	452	323					
Height at withers							
	inches	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*
I	28.7	30.4	29.9	26.5	28.1	29.1	28.6
II	30.7	31.5	32.5	27.5	29.0	31.4	30.7
III	32.9	33.3	35.0	29.4	30.4	33.5	32.2
IV	34.8	34.1	37.0	30.9	30.7	35.7	35.7
V	36.4	33.2	38.7	33.5		38.0	39.0
VI	38.4	36.4	40.5	35.0		40.8	
VII	39.8	40.2	42.8	36.2			
VIII	41.0	40.4	44.3				
IX	42.0	42.0					
Depth of chest							
I	11.4	12.1	13.0	10.2	11.0	12.1	11.9
II	12.8	13.5	14.0	11.5	11.3	13.9	13.0
III	14.2	14.9	16.0	13.1	13.2	15.8	15.1
IV	15.4	15.7	17.2	14.4	13.8	17.1	16.6
V	16.7	16.7	18.4	15.0		18.2	17.8
VI	17.9	17.8	19.3	15.5		20.0	
VII	18.7	18.7	20.3	16.2			
VIII	19.5	18.6	20.5				
IX	20.3	19.3					

TABLE 40—*Continued*

PERIOD	GROUP						
	Normal	Lot I		Lot II		Lot III	
		Calf 479	Calf 489	Calf 498	Calf 502	Calf 488	Calf 495
	Width at hooks						
	inches	inches	inches	inches	inches	inches	inches
I	6.7	6.5	7.4	5.9	6.3	6.8	6.9
II	7.5	7.3	8.6	7.0	6.9	7.8	8.0
III	8.5	8.0	9.8	8.1	7.1	9.0	9.6
IV	9.4	8.3	11.1	8.7	7.1	10.4	10.9
V	10.2	8.9	11.1	9.1		11.9	11.4
VI	11.2	9.8	11.4	10.0		13.0	
VII	11.8	9.9	12.4	10.4			
VIII	12.6	10.4	13.2				
IX	13.2	11.1					

In order that some idea may be gained as to the relative rates of increase in live weight and body measurements of the calves it is necessary that some standard be used with which they may be compared. For this purpose the averages of similar measurements obtained on 40 normally fed heifers are included. This should form a satisfactory basis of comparison as all the experimental calves were young and the bulls were castrated so that it is not probable that sexual development would cause the two groups of figures to vary relatively.

Live weights and body measurements. When lot I is considered it is found that both animals is this group were heavier at birth then the average for the normal group. Calf 479 maintained its lead for only two months and then dropped below normal and continued to do so until alfalfa hay was introduced at the beginning of period VIII when it started to regain in rate of growth, calf 489, the heaviest of all, increased in live weight slowly and at the end of period V was of the same weight as the normal calves were at the end of period VI. During period VI, alfalfa was introduced and it immediately started to gain rapidly.

Both animals in lot II, though one was heavier and one lighter than the average for the normal group, fell far behind the normal weights as the work progressed. The calf 502 died, while no.

498 was given alfalfa at the end of period V and when the trial closed at the end of period VII it was beginning to approach the normal group in weight.

The alfalfa fed animals in lot III, though slightly lower in birth weight than the average for the normal group, always exceeded the normal group in live weight from the end of period I.

In regard to the body measurements it may be said that they did not vary uniformly though there was a very decided increase in the rates of growth of the calves in lot III compared with the normal calves, while the calves in lot II lagged behind the check. The calves in lot I did not show a great variation from the check group.

Increase in live weight and body measurements. The animals in lot III, fed alfalfa and milk throughout, showed a greater percentage increase in live weight and body measurements than did the normal group. In lot II, calf 502 showed a slower percentage increase than normal and eventually died. The other animal in this lot, calf 498, showed slow percentage gains in height but the other measurements were near normal, while the percentage increase in body weight was accelerated by the introduction of alfalfa hay into the ration. In lot I the percentage increases in live weight were good towards the start but started downwards and then recovered greatly on feeding alfalfa hay, the greatest recovery being in the case of the calf started on hay at the younger age. In the body measurements of this group the tendencies were quite similar.

Condition and behavior of calves

Certain results brought about by the rations fed to the animals were most noted in physical characteristics, other than weight and body measurements, and in their body activities and general behavior.

Lot I—milk. In the early part of period III, calf 479 showed a ravenous appetite for shavings and started to eat hair from no. 489 and the faeces were very thin. The animal was quite thin but the muscles were firm. By the beginning of period IV, no. 479 began to lie down considerably. The faeces were

TABLE 41

Percentage increase in live weights and body measurements

PERIOD	GROUP						
	Normal	Lot I		Lot II		Lot III	
		Calf 479	Calf 489	Calf 498	Calf 502	Calf 488	Calf 495
Increase in live weight							
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
I	34	24	45	35	4	71	46
II	79	63	91	80	22	152	120
III	143	112	155	151	65	265	223
IV	215	120	219	224	66	388	309
V	291	179	271	267		505	421
VI	369	232	349	331		611	
VII	446	249	444	396			
VIII	516	280	524				
IX	575	325					
Increase in height at withers							
II	7	4	9	4	3	8	8
III	15	10	20	11	8	15	13
IV	21	12	24	17	9	23	25
V	27	9	29	26		31	36
VI	34	20	36	32		40	
VII	39	32	43	37			
VIII	43	33	48				
IX	46	38					
Increase in depth of chest							
II	12	12	8	13	3	15	9
III	25	23	23	28	20	31	27
IV	35	30	32	41	25	41	39
V	47	38	42	47		50	50
VI	51	47	48	52		65	
VII	64	55	56	59			
VIII	71	54	58				
IX	78	60					
Increase in width at hooks							
II	12	12	16	19	10	15	16
III	27	23	32	37	13	32	39
IV	40	28	50	47	13	53	58
V	52	37	50	54		75	65
VI	67	51	54	69		91	
VII	76	52	68	76			
VIII	88	60	78				
IX	97	71					

watery and a slate grey in color. The muscles were firm but there was no apparent body fat and the calf started to chew the wooden walls of the pen. In period VI, no. 479 had taken practically all the hair from the back of no. 489 and attempted to cud. This was probably due to the hair and wood eaten.

In period II, calf 489 showed a depraved appetite and in the early part of period III became weak in the knees when led,

FIG. 1. CALF 489 IN LOT I

This shows the low condition the calf was in after continuous feeding of milk alone for five months.

and down in the front pasterns. Later in the period its gait became stilted and the legs were stiff at the knees and hocks. The skin was very sensitive and twitched when touched, especially along the spinal column. By period V, calf 489 had become quite listless but was erratic to handle.

Within a few hours of the introduction of alfalfa hay to the ration, these calves were chewing the cud and continued to improve from that time on.

Lot II—milk and grain. The calves in this group may be treated separately. In the early part of period III, calf 498 had a good appetite and was in good condition but showed a craving for roughage. It chewed its cud slightly, probably due to eating shavings used as bedding at that time, but they were removed. In the early part of period V the leg joints became swollen and the calf could not stand straight. The knees were bowed outward and forward. The appetite was good but the faeces thin. When

FIG. 2. CALF 489 IN LOT I

A marked improvement is noted in the calf after alfalfa hay has been fed with the milk for three months.

this calf was put on hay at the beginning of the sixth period, it began to improve and at the end of period VII it was in good condition.

In the early part of period II, calf 502 began to chew the boards of the pen and to cud to a small extent. At this time it had a good appetite though it was thin and its hair on end. Its vitality kept lowering until in the early part of period V it began to bloat

and this eventually became habitual and caused much pain. It became weak in the legs, unable to rise, eventually lost all control of the hind quarters, and died.

FIG. 3. CALF 498 IN LOT II

Deformation of the bones of the front legs is very evident after the feeding of milk and grain for five months.

Lot III—milk and alfalfa ration. The animals in this group were in good thrifty condition throughout the trial and always maintained a sleek glossy coat. Their faeces were normal though alfalfa hay in this section is sometimes not the best for calf raising as it at times tends to produce scours.

FIG. 4. CALF 498 IN LOT II
This shows further bone deformation

Post-mortem examination of calf 502 in lot II

A post-mortem examination was conducted on calf 502 immediately after death, by Drs. B. A. Benbrook and H. D. Bergman of the Veterinary Division.

The stomach. In the stomach as a whole the mucous membrane, folds and papilli were all apparently normal. The musculature of the wall of the rumen was not well developed. The rumen was about one-third undersized and distended with gas. The contents were dry and consisted mainly of oat hulls and some grain. The musculature of the wall of the reticulum was

not normally developed, but the compartment approached nearer to normal than did the rumen. The omasum was also undersized. The abomasum was apparently fully developed and contained about a quart of fluid very similar in appearance to bile and contained a sediment of cinders showing that a depraved appetite had caused the calf to eat the cinders used for bedding in the

FIG. 5. CALF 498 IN LOT II

After alfalfa hay had been added to the ration for two months, the leg bones of this calf came back to normal and it improved in other ways.

latter part of the experiment. Derangement of the mechanism of the pylorus or hyperacidity of the stomach might explain the presence of the bile-like fluid in the abomasum.

The intestine. Catarrhal enteritis was apparent throughout the intestinal tract. The contents of the small intestine were fluid and yellowish in color with small orange-yellow flaky bodies occurring in the fluid. This fluid was apparently largely secreted from the intestinal walls. The contents of the caecum

appeared drier than normal. The amount of faeces in the rectum was also small.

The glands. The liver was slightly enlarged, of lighter color than normal, soft, friable, and had a cloudy swelling, due to congestion. The gall bladder was about 4 times normal size and contained about $1\frac{1}{2}$ pints of fluid. The bile was light yellow and flocculent, instead of greenish in color. Catarrhal infection caused swelling that almost entirely closed the opening of the

FIG. 6. CALF 488 IN LOT 111

This calf raised on milk and alfalfa was always in good thrifty condition.

bile duct into the duodenum and pressure on the gall bladder would force only a small amount of fluid into the duodenum. The wall of the gall bladder showed slight hemorrhages.

The kidneys showed no marked changes but the urine in the bladder was slightly cloudy and there was a slight congestion of the blood vessels in the bladder wall.

A hyperstatic condition existed in the principal lobe and most of the anterior lobes in the lower border of the right side of the lung. The remainder of the lung tissue was edematous.

Hemorrhages occurred in the epicardium and endocardium and were especially evident in the lining of the left ventricle. They were due to infection. The blood vessels in the walls of the gall bladder, in the walls of the bladder and in the mesentery, showed hemorrhages due to infection and weakening of the walls of the blood vessels. The blood was darker than normal and slow to coagulate. This was due to an infection destroying the enzyme thrombrokinase, which enters into the clotting process.

The spleen was enlarged, due to destruction of red blood cells in large quantities as the result of infection. The rapid destruction of red blood cells results in greater production of these cells in the bone marrow and consequently the bone marrow was slightly red instead of being the normal yellow color for a calf of this age.

General. The muscles were slightly yellow and edematous, possibly due to a leakage of blood serum. The knee and ankle joints appeared to be normal in both capsule and bone. The femur of the right hind leg was broken just below the hip joint and appeared to have been broken about two days before death. There was some hemorrhage and laceration about the broken part. The wall of the femur where broken was thinner than in a normal calf of the same age. A section of the radius, just below the left knee was taken for a breaking test.

Cause of death. The immediate cause of death was a non-specific septicaemia arising from organisms normally present in the bovine body. Owing to the weakened condition of the calf these organisms were allowed to develop unduly. The immediate cause of death was this non-specific septicemia which developed owing to the lowered vitality induced by undernutrition.

Breaking test of bone. The bone sample taken from the radius, just below the left knee of calf 502, was given both the breaking and crushing tests by Prof. J. H. Griffith of the Engineering Division.

The sample of bone used was $6\frac{1}{2}$ inches long and $2\frac{9}{16}$ inches at its smallest circumference. The bone had been removed from the body about a day before the breaking and crushing tests were made.

In the breaking test the bone was placed on blocks with a 5-inch span. A $\frac{5}{8}$-inch bar laid crosswise sustained the force applied from above. The bone bent, cracked and finally broke with a variable load of from 190 to 640 pounds per square inch. The flexibility of the bone was largely due to the low content of ash constituents.

In the crushing test the weight was applied on the bone $2\frac{1}{2}$ inches from the upper articulation by means of $\frac{3}{8}$-inch flat iron bar with rounded edges. The bone crushed with a load of 400 pounds per square inch. The bone was 3 inches in circumference at the crushing point, with the wall of the shaft varying around $\frac{3}{32}$ inch in thickness at the point of crushing. The bone shaft at this point was $1\frac{1}{16}$ inches wide and $\frac{5}{8}$ inch thick.

DISCUSSION OF RESULTS

It has been shown that milk as the sole ration for calves is unsuitable and that a ration of milk with a grain mixture of corn, oats, wheat bran and old-process linseed oil meal is even less valuable, while the addition of alfalfa hay to these two rations will render them quite well adapted to the needs of the growing calf. An explanation of the differences in the value of the rations is by no means easy.

The first point to note is the amount of nutrients consumed by the calves. From the feed data and the analyses given by Henry and Morrison (48) this information was obtained and from the same source the actual requirements of the calves were determined as in paper V of this series. The percentage variation of the amount of nutrients consumed from the requirements of the calves were then obtained for each thirty-day period.

Lack of bulk

To prevent confusion it should be stated that there is a distinction between the bulk of a feed and the dry matter it contains. The dry matter is simply the sum of the water-free constituents present, while the bulk of a ration is indicated by the weight of the feed which will fill a given unit of volume. Thus 100 pounds

TABLE 43

Percentage increase in nutrients provided in addition to requirements

PERIOD	LOT I						LOT II						LOT III					
	Calf 479			Calf 489			Calf 498			Calf 502			Calf 488			Calf 495		
	D. M.	D. N.		D. M.	D. N.		D. M.	D. N.		D. M.	D. N.		D. M.	D. N.		D. M.	D. N.	
		Cr. P.	C. E.		Cr. P.	C. E.		Cr. P.	C. E.		Cr. P.	C. E.		Cr. P.	C. E.		Cr. P.	C. E.
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
I	31	44	50	3	12	33	16	26	33	−1	9	12	7	14	20	47	88	57
II	32	43	50	10	17	14	4	8	14	39	32	47	47	111	47	86	187	82
III	8	15	21	−31	5	11	29	14	27	58	39	53	47	143	26	36	253	65
IV	−30	5	12	−51	−17	−10	46	15	31	71	39	58	6	307	41	25	295	64
V	−29	8	13	−62	−22	−28	1	9	25				10	446	41	−4	364	24
VI	−49	−13	−6	−52	69	−21	14	114	28				10	483	41			
VII	−57	−12	−18	−28	122	4	−5	165	22									
VIII	−23	151	18	−24	283	1												
IX	−20	218	17															

D. M., Dry matter.
D. N., Digestible nutrients.
Cr. P., Crude protein.
C. E., Carbohydrate equivalent.

of corn and 100 pounds of alfalfa hay are of the same weight but the corn occupies considerably less space than the hay and so the alfalfa hay is classed as a bulky feed.

The calves in lot I had an oversupply of digestible nutrients until the end of period V in the case of calf 479 and until the end of period III with calf 489. At those times the supplies of nutrients became deficient and continued to be so until alfalfa was added to the ration, even though the calves were receiving all the milk they could handle. The excess of nutrients that was at first supplied decreased gradually while the excess of dry matter decreased more rapidly and at an early stage in the experiment too little dry matter was being allowed, when milk alone was fed. As alfalfa was added to the ration the deficiency in the supply of dry matter gradually decreased and when the calves had come back into good condition the dry matter deficiency was rapidly disappearing. In other words, the bulky hay apparently aided in the recovery of the calves, in lot I, due to the fact that the additional bulk helped to expand the rumen and other portions of the digestive tract and render the calves capable of handling the nutrients with which they were provided. This necessary bulk was not present when the sole ration of the calves was milk.

It should be noted that calf 479 was always behind normal in live weight increase, but after alfalfa was added to the ration it came nearer to normal. Calf 489 was above normal at the start but decreased relatively in live weight until alfalfa was added in period VI when it started to increase rapidly in live weight and at and end of the trial was above normal.

In lot II where milk and grain were fed there were only a few times at which the supply of dry matter was deficient. There was a slight deficiency in the last period for calf 498 and in the first period for calf 502. The dry matter these calves received was not of a bulky character and calf 502 died in period V, although it had an ample supply of nutrients throughout the trial.

In the case of calf 498 the fair excess of nutrients available at the start decreased irregularly until in period V there was an excess of only 1 per cent of dry matter in the ration. Alfalfa

hay was then added and there was a great increase in digestible crude protein and also in other nutrients. The amount of dry matter was also increased though it went below the requirements in the last period, perhaps due to increasing capacity on the part of the calf.

The calf 502 was always below normal in live weight increase while the calf 498 maintained a good rate of increase for a time but dropped below normal in period V and then on the addition of alfalfa hay increased in live weight in a manner more nearly normal.

Evidently the addition of the grain mixture to the milk ration not only did not provide sufficient bulk but it had other bad effects as the calves did not do as well as those on milk alone. The addition of a bulky feed produced good results, however.

The calves in lot III were provided with plenty of bulk and, with but one exception, with plenty of dry matter, as they had a ration of milk and alfalfa hay from the start. In the rate of live weight increase they kept well ahead of the normal calves.

Thus far the data presented would indicate that the presence of sufficient bulk in the ration is absolutely necessary for young growing calves.

Quality of ash

The quantity and the quality of the ash fed in the ration to animals has a considerable influence on the ultimate benefit of the feed to the animal and one of the important factors to note is the calcium-magnesium ratio in the rations of the various groups. For the determination of this ratio the figures on the lime and magnesia contents of feeds given by Henry and Morrison (48) are used.

In considering the ratio of the lime (CaO) to magnesia (MgO) in the rations, the lime content is taken as unity. It was found in the case of lot I that the ratio was 1:0.1, or in other words, there was 10 times as much lime as magnesia in the ration when milk alone was fed. When alfalfa hay was added the ratio changed to 1:0.2 or 1:0.3, or in other words, there was 5 to 3

times as much lime as magnesia. In lot III the ratios found were very similar in some respects to those in the later periods for lot I, the ratio being generally 1:0.2 or 1:0.3.

With lot II the lime-magnesia ratio changed to 1:0.4 in the case of calf 502 just before its death and to 1:0.6 for calf 498 in period V. At this time calf 498 cut its grain consumption considerably and in the next period the ratio was 1:0.4, while in the following period it was back to 1:0.3 on the addition of alfalfa hay to the ration.

These results appear to be in accord with those of Forbes (43). When an excess of magnesium in proportion to the calcium is provided, the excess of magnesium is removed by a counteractive liberation of calcium from the tissues, especially the bone,

TABLE 43

Lime and magnesia per 1000 pounds of feed. After Henry and Morrison (48)

	FEED					
	Milk*	Corn	Oats	Bran	Oil meal	Alfalfa hay
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Lime	1.8	0.2	1.4	0.9	5.1	19.5
Magnesia	0.2	1.8	2.0	7.3	8.1	5.9

* Taken to be the same as in skim milk.

and this may lead to malformation of the bones, especially of the legs. Such malformations of the legs were quite noticeable in the case of calf 498 before alfalfa was added to the ration (figs. 3 and 4), but on its addition the bones of the legs showed marked improvement (fig. 5). This would indicate that a ration of milk and the grains used is not only deficient in bulk but also lacks the proper balance of lime and magnesia in the ash and is even less suited for growing calves than a ration of milk alone.

Vitamine supply

Another very important factor so far as the nutrition of the calves in this study is concerned is the supply of vitamines, as there is a possibility that the calves might not have been provided with sufficient of them.

TABLE 44

Lime-magnesia ratio in rations

PERIOD	LOT I						LOT II						LOT III					
	Lime		Magnesia		Ratio		Lime		Magnesia		Ratio		Lime		Magnesia		Ratio	
	Calf 479	Calf 489	Calf 479	Calf 489	Calf 479	Calf 489	Calf 498	Calf 502	Calf 498	Calf 502	Calf 498	Calf 502	Calf 488	Calf 495	Calf 488	Calf 495	Calf 488	Calf 495
I	0.63	0.60	0.07	0.07	0.1	0.1	0.39	0.39	0.04	0.04	0.1	0.1	0.54	0.73	0.06	0.11	0.1	0.2
II	0.81	0.88	0.09	0.10	0.1	0.1	0.44	0.49	0.06	0.09	0.1	0.2	1.36	1.51	0.25	0.30	0.2	0.2
III	0.87	1.08	0.10	0.12	0.1	0.1	0.53	0.53	0.15	0.17	0.3	0.3	2.23	2.68	0.52	0.66	0.2	0.2
IV	0.97	1.13	0.11	0.13	0.1	0.1	0.57	0.56	0.28	0.25	0.5	0.4	4.40	4.09	1.18	1.08	0.3	0.3
V	1.13	1.13	0.13	0.13	0.1	0.1	0.60		0.37		0.6		5.96	5.10	1.65	1.39	0.3	0.3
VI	1.13	2.01	0.13	0.27	0.1	0.1	1.72		0.62		0.4		6.91		1.94		0.3	
VII	1.13	4.04	0.13	1.01	0.1	0.3	2.64		0.81		0.3							
VIII	2.81	5.11	0.64	1.33	0.2	0.3												
IX	3.49		0.84		0.2													

In considering all lots it may be said that butterfat is still regarded as the most important source of fat-soluble A and this is clearly demonstrated in the compilation of Blunt and Wang (34). It may be allowed therefore that the calves had sufficient of this vitamine.

Milk is not too rich in water-soluble B according to Osborne, Mendel, Ferry and Wakeman (50) but there should have been sufficient of it present to carry the various groups in good condition. It is perhaps also true that the water-soluble C present may have been sufficient according to Chick, Hume, Shelton and Smith (37 and 38).

When the other feeds in addition to milk are considered it is noted that the yellow corn fed to lot II contained fat-soluble A according to Steenbock and Boutwell (53), although this was already present in the milk. The cereals provided would also furnish the calves with additional water-soluble B according to Osborne and Mendel (49) but the bran would be of no value in this respect according to Briggs (32). The oats and other grains would not add any water-soluble C according to Harden and Zilva (44). As a consequence, therefore, lot II was probably provided with more fat-soluble A and water-soluble B than lot I but they did not do as well and so the deficiencies of milk as the ration of lot I cannot be attributed entirely to the lack of these vitamines.

In the third lot alfalfa hay was fed in addition to the milk and these calves did well and the animals in lots I and II, which had reached a very low degree of vitality, recovered when alfalfa was fed. Alfalfa contains fat-soluble A according to Steenbock and Boutwell (53) but this was already present in the milk. Water-soluble B occurs in considerable amounts in immature alfalfa but in less amounts when it is mature as has been stated by Osborne and Mendel (49) and undoubtedly much of this is lost in haymaking and storage and so it is doubtful if the alfalfa improved the ration so far as water-soluble B is concerned.

Alfalfa also contains water-soluble C but Chick, Hume, Shelton and Smith (38) and Delf and Shelton (40) state that when the living tissues are disorganized by drying the water-soluble C

is destroyed. Consequently the alfalfa hay would apparently be of little value to the calves as a source of this vitamine. The alfalfa hay was the feed which produced the greatest growth and brought the calves that were below normal back to normal and yet it would appear that this was not entirely due to any vitamines which it might supply.

From the results obtained in this work it would appear that though milk is a poor ration for calves after they are a few weeks old, the addition of a grain mixture such as that used will give even poorer results. On the other hand, the feeding of alfalfa gave good results.

It would appear that the benefits of alfalfa do not lie entirely in the provision of more nutrients or in improving the vitamine supply. The alfalfa provides bulk which keeps the digestive tract of the calf distended and in proper condition for the handling of feed. The grain used produced bad effects by increasing the relative amount of magnesium as compared with calcium in the ration.

SUMMARY

From the work reported here it would appear that the following deductions are possible:

1. Milk though a suitable ration for young calves cannot maintain ruminants indefinitely.

2. The addition of a grain mixture of corn, oats, bran and oil meal to a ration consisting solely of milk impairs the growth of the calves and leads to death even more rapidly than a ration of milk only.

3. The cause of the earlier death on the addition of the grains is probably due to the depletion of the body stores of calcium due to the fact that the grains contain more magnesium than calcium and calcium must consequently be drawn from the body, especially the bones, to take care of this excess of magnesium.

4. The addition of alfalfa hay to a ration of milk or of milk, corn, oats, bran and oil meal will bring back to good growing condition animals which have fallen to a low place of nutrition on the rations mentioned.

5. Milk and alfalfa hay can be used to grow out calves satisfactorily.

6. The beneficial effects of the alfalfa hay are apparently not due absolutely to the nutrients it supplies as an abundance of nutrients had been provided in the other experimental rations.

7. It is apparently not probable that the alfalfa hay adds in appreciable amounts vitamines which might have been absent from the other rations used.

8. Where alfalfa is added to a ration of milk and the grain mixture used, it would appear that part of the beneficial effect of the alfalfa is due to the fact that it increases the calcium content as compared to the magnesium content of the ration and thus conserves the calcium stores of the body.

9. The main advantage derived from the alfalfa hay seems to be due to the fact that this feed, being bulky in character, helps to distend the digestive tract of the calf and so renders proper digestion possible.

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DAIRY NOTES

PENNSYLVANIA. J. R. Dawson, who has been extension dairyman at the Pennsylvania State College, has recently resigned to accept a position with the United States Department of Agriculture.

INDIANA. R. D. Canan, who has been field man for the American Jersey Cattle Club at Indianapolis, has recently resigned to take up dairy extension work in Indiana.

TENNESSEE. J. J. Hooper, chairman of the Committee on Students Dairy Cattle Judging Contests, Southern Division American Dairy Science Association, reports the establishment of a dairy cattle judging contest for the Agricultural Colleges of the South to be held in connection with the Tri-State Fair at Memphis, Monday, September 24, 1923.

Rules and regulations to govern the contest will be the same as those governing the National Contest. Premiums will consist of handsome trophies for (1) team ranking highest in all breeds, (2) highest on Jerseys, (3) highest on Holsteins, (4) highest on Guernseys. Gold medals will be awarded the individuals ranking highest in these four places.

ANNUAL MEETING OF THE SOUTHERN DIVISION, AMERICAN DAIRY SCIENCE ASSOCIATION

The second annual meeting of the Southern Division, American Dairy Science Association was held at Chisca Hotel, Memphis, Tenn., February 7, 1923, and was called to order by President C. W. Holdaway of Virginia at 2:00 p.m., and the minutes of the previous meeting were read and accepted.

Professor Holdaway in his address briefly outlined the history of the association, the development of its divisions, and the particular problems confronting the Southern Division workers, stressing the need of specialized dairy instruction in southern schools.

A discussion of stock judging was led by Dan T. Gray, director of Animal Industry, Auburn, Ala., who emphasized the need of standardization of methods and the value of pedigrees. On motion of J. A. Gamble, presiding officer E. S. Good was instructed to appoint a committee to study this matter and report its findings at the meeting next year.

J. H. McClain dealt briefly with the dairy problems peculiar to the South, especially the production of quality butter against which no discrimination will be made in northern markets. He urged the importance of increased production through better feeding and breeding, and suggested research work to determine just how impotency of sires brought down from the North can be overcome.

Stanley Combs proposed the appointment of a committee to study the influence of feeds on butter texture, and suggested a combination of cottonseed meal and soybeans to overcome common defects of southern butter. He further emphasized the need for increased consumption of milk by children of the South and the importance of home-mixed vs. ready-mixed rations for dairy cattle.

For better marketing Mr. Combs suggested that some commission house be induced to specialize in handling southern butter. Professor Dvorachek of Arkansas cited that state's experience in securing better butter through a system of cream grading whereby a premium was paid for the better grades of cream. C. A. Hutton of Tennessee endorsed this system and said that when farmers are convinced that southern butter can be good and will take care in handling their milk and cream, good butter will automatically result.

R. S. Curtis of Raleigh, N. C., then summarized his findings on the coördination of teaching, experimental and extension work in the South. A. O. Jamison discussed rational milk control, pointing out that pasteurization is a godsend to the dairy industry. Factors affecting the official butterfat tests of cows were presented by C. E. Wylie and aroused considerable comment. This paper is found in full on page 292 of this issue.

Results of experimental work to note the effect of cottonseed meal upon the growth and reproduction of cows were given by Professor Combs. This paper will be submitted for publication in a later issue.

C. E. Wylie, chairman of the Committee on Feeding, presented a report recommending (1) a careful study of the pasture situation and the introduction and development of the best pasture grasses for southern conditions, (2) experiments to determine the value of silage in the South, (3) attention to proper housing and management of dairy cattle, (4) further study of the relation of feeds to production of good butter.

"Dairy Statistics of the Southern States and Their Significance to the Dairy Industry of the United States," was the topic of a report read by R. C. Potts of the Bureau of Markets, United States Department of Agriculture; and G. P. Warber, Virginia Polytechnic Institute, Blacks-

burg, Va., presented a paper on "Rational Control of Fluid Milk Supply of Cities."

By-laws governing the Southern Division were adopted, and resolutions passed recognizing the importance of livestock to profitable southern agriculture both through increased production due to restoration of fertility to the soil and through direct revenue from products sold; and hearty support of efforts to solve southern probems of production and marketing was urged.

The following officers were elected: Chairman, C. E. Wylie, Knoxville, Tennessee; Vice-chairman, J. P. LaMaster, Clemson College, South Carolina; Secretary, J. A. Gamble, College Park, Maryland.

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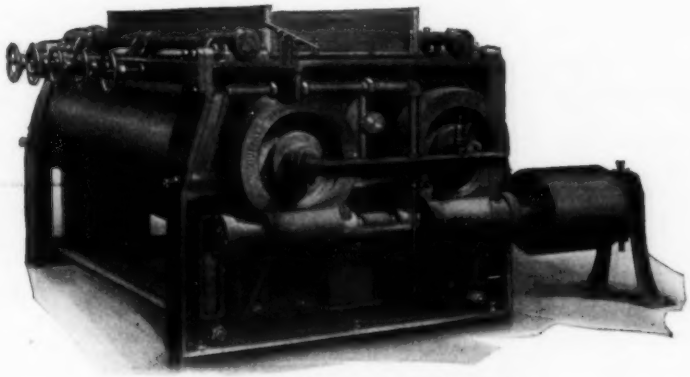

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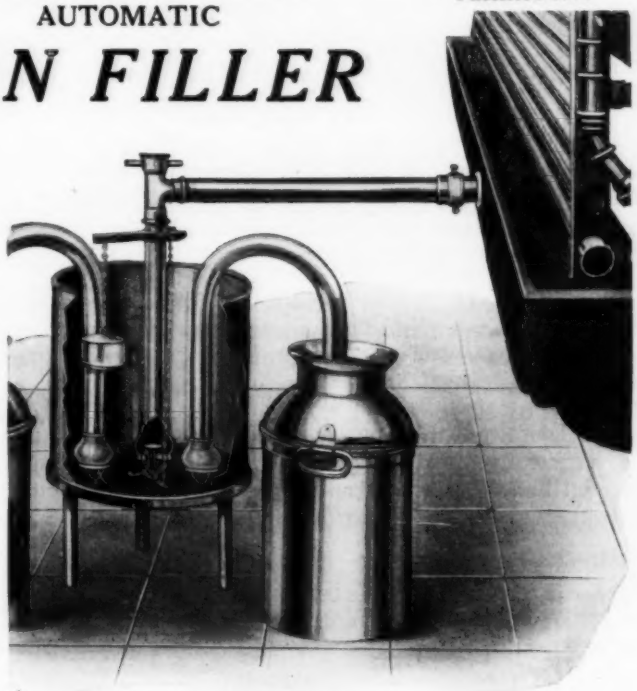

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